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Bogs and Fens of New Hampshire

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SUMMARY

Peatlands have been the subject of extensive discussion in the scientific literature over the past 100 years. Peatland classification has been one of the main themes of this literature, although the peatland features emphasized have varied between classifications. Most of these classifications have utilized some combination of associated landforms, vegetation, hydrology, peat development and stratigraphy, chemistry, and climatic factors. While there is an abundance of literature on peatlands both regionally and globally, there has been relatively little published on New Hampshire peatlands.

The primary goal of this project was to develop a *statewide* classification of the natural communities occurring within open peatlands. This classification is intended to facilitate future surveys of particular geographic areas and to inform protection and management decisions concerning peatlands in New Hampshire. As most peatland sites consist of several to many different individual community types, the NH Natural Heritage Inventory (NH Heritage) also developed a classification of broad peatland ecosystem types that can be used to describe whole peatland complexes. Funding for this study was provided by the U.S. Environmental Protection Agency through the State Development Wetland Protection grant program.

New Hampshire's peatlands are generally topogenous (fed in part by topographic runoff) or limnogenous (associated with lakes, ponds, and streams). A few peatlands in New Hampshire are soligenous (dependent on a reliable source of seepage water). No true raised, ombrogenous (rain-fed) peatlands are known in the state; however, some large peatlands in central and northern New Hampshire warrant closer examination to determine if they have such tendencies.

Nutrient regime and degree of saturation were important variables associated with open peatland communities in New Hampshire. These gradients are implied indirectly by species composition differences, pH, shrub height, micro-relief (hummock-hollow development), and degree of decomposition of the upper meter of peat. Variation in these factors was closely associated with community classification based on species composition. A sparse or absent dwarf shrub layer was associated with wet, usually acidic conditions, while height and density of shrubs increased with higher pHs or drier conditions. Tall shrubs and sedge-dominated fens were associated with more minerotrophic conditions.

The peatland natural community classification groups communities into five groups based on vegetation structure: (1) mud-bottoms, open moss lawns, and flarks; (2) dwarf- and medium-shrub bogs and poor fens; (3) sedge and shrub/graminoid fens; (4) tall shrub thicket/sparse woodlands; and (5) marshy peatland marginal communities. There are 26 natural community types within these groups, which are arranged in the classification by trophic level (ranging from oligotrophic to minerotrophic). Many community types are widespread, some are geographically restricted, and a few are state and regionally rare. Rare types include calcareous patterned fen, acidic patterned fen, calcareous sedge/moss fen, all sloping and level alpine/subalpine peatlands, montane peatlands dominated by *Calamagrostis pickeringii* (Pickering's reed bent-grass), and some intermediate fens and seepage marshes.

We also describe four broad groups of peatlands and 11 ecosystem types based on repeating combinations of communities that tend to occur together at single sites or basins. These ecosystem types can be useful for comparing whole sites and informing peatland protection efforts.

There are many rare vascular plants associated with peatlands, and several rare *Sphagnum* moss species. *Sphagnum* mosses are the main peat-forming plants in bogs and fens, exert considerable control on the formation and development of peatlands, and are sensitive indicators of environmental conditions. This project greatly facilitated the development of New Hampshire's first comprehensive list of the genus *Sphagnum* (Cleavitt *et al. In press*) through a collaborative effort between NH Heritage ecologists and bryologists from other institutions. Peat mosses are enormously important to understanding peatlands, and this checklist helped direct field work and informed the development of our classification.

Classification of New Hampshire's Open Peatlands

MUD-BOTTOMS, OPEN MOSS LAWNS, AND FLARKS

Oligotrophic Types (Very Acidic)

Cladopodiella fluitans/Utricularia cornuta mud-bottom

Sphagnum rubellum/Vaccinium oxycoccus dwarf heath moss lawn

Oligotrophic–Weakly Minerotrophic Types (Acidic)

Sphagnum pulchrum/Carex moss lawn

Sphagnum cuspidatum/Vaccinium macrocarpon moss lawn

Sphagnum torreyanum/Vaccinium macrocarpon/Rhycospora alba moss lawn

Minerotrophic Types (Circumneutral–Calcareous)

Circumneutral-calcareous flark

DWARF- AND MEDIUM-SHRUB BOGS AND POOR FENS

Oligotrophic Alpine/Subalpine bogs and Subalpine Heath snowbanks (Very Acidic)

Wet alpine/subalpine level and sloping bog

1. Rubus chamaemorus-Scirpus cespitosus-Vaccinium uliginosum variant
2. Rhododendron canadense/shrub heath variant

Subalpine wooded heath snowbank, slope bog, and bog margin

Subalpine sliding fen

Oligotrophic–Weakly Minerotrophic Mid-Low Elevation Bogs and Poor Shrub Fens (Very Acidic–Acidic)

Chamaedaphne calyculata-Kalmia angustifolia/Sphagnum capillifolium dwarf heath shrub bog

1. Dwarf-medium heath shrub bog variant
2. Dwarf heath shrub bog variant
3. Weakly minerotrophic heath shrub poor fen variant

Chamaedaphne calyculata-Kalmia angustifolia/Picea mariana dwarf heath shrub bog/very poor fen

1. Sphagnum rubellum-S. angustifolium dwarf heath variant
2. Ledum groenlandicum-Sphagnum fuscum dwarf heath variant

Intermediate–Minerotrophic (Circumneutral) Type

Thuja occidentalis circumneutral string

SEDGE AND SHRUB/GRAMINOID FENS

Weakly Minerotrophic Types (Acidic)

Andromeda glaucophylla-Myrica gale/Carex utriculata/Sphagnum fallax fen

Myrica gale-Spiraea alba/Carex stricta streamside/pond-border fen

Decodon verticillatus/Sphagnum recurvum-S. flexuosum border thicket

Montane Calamagrostis pickeringii/shrub level/sloping fen

Intermediate Types (Subneutral)

Carex lasiocarpa/Myrica gale-Vaccinium macrocarpon sedge fen

Intermediate–Minerotrophic (Mesotrophic) Types (Circumneutral–Calcareous)

Calcareous sedge/moss fen

1. Sloping typic variant
2. Level/shallow sloping deep peat variant
3. Steep slope Equisetum variant
4. Beaver meadow variant

Graminoid-forb-sensitive fern seepage marsh

TALL-MEDIUM SHRUB THICKET/SPARSE WOODLANDS

Oligotrophic–Weakly Minerotrophic Types (Very Acidic–Acidic)

Vaccinium corymbosum-Nemopanthus shrub thicket/sparse woodland

1. Rhododendron canadense-Nemopanthus mucronatus-Sphagnum russowii variant
2. Vaccinium corymbosum-Gaylussacia baccata-Vaccinium macrocarpon variant

Montane Tall Shrub Thicket/Sparse Woodlands

Montane heath shrub thicket/sparse woodland

Montane alder-heath shrub thicket

Weakly Minerotrophic–Intermediate Types (Acidic–Subneutral)

Ilex verticillata/Osmunda cinnamomea/Picea tall shrub thicket/sparse woodland

Ilex verticillata/Osmunda cinnamomea/Sphagnum fallax tall-medium shrub thicket

Vaccinium corymbosum/Myrica gale-Spiraea alba tall-medium shrub thicket

MARSHY PEATLAND-MARGIN COMMUNITIES

Floating marshy peat mat

Marshy moat

INTRODUCTION

Peatlands have been the subject of extensive discussion in the scientific literature over the past 100 years. Peatland classification has been one of the main themes of this literature, although the peatland features emphasized have varied between classifications. Most of these classifications have utilized some combination of associated landforms, vegetation, hydrology, peat development and stratigraphy, chemistry, and climatic factors. While there is an abundance of literature on peatlands both regionally and globally, there has been relatively little published on New Hampshire peatlands.

The primary goal of this project was to develop a *statewide* classification of the natural communities occurring within open peatlands. This classification is intended to facilitate future surveys of particular geographic areas and to inform protection and management decisions concerning peatlands in New Hampshire. As most peatland sites consist of several to many different individual community types, we also developed a classification of broad peatland ecosystem types that can be used to describe whole peatland complexes. Funding for this study was provided by the U.S. Environmental Protection Agency through the State Development Wetland Protection grant program.

This project also greatly facilitated the development of New Hampshire's first comprehensive list of peat mosses (the genus *Sphagnum*) (Cleavitt *et al*. *In press*) through a collaborative effort between NH Heritage ecologists and bryologists from other institutions. Sphagnum mosses are the main peat-forming plants in bogs and fens, exert considerable control on the formation and development of peatlands, and are sensitive indicators of environmental conditions. As such, peat mosses are enormously important to understanding peatlands and this checklist helped direct field work and informed the development of our classification.

PREVIOUS PEATLAND CLASSIFICATIONS IN NEW HAMPSHIRE

Recent, broad treatments of peatlands of the region that are applicable to New Hampshire include Johnson (1985) and Damman and French (1987). Both describe the development, ecology, and vegetation of bogs in the northeastern United States. Damman and French (1987) describe five broad types of peatlands based on the structure of the vegetation: (1) moss carpet, (2) graminoid, (3) dwarf shrub, (4) tall shrub, and (5) forest. Within each, several finer-scale plant communities are described. While this classification is generally applicable to New Hampshire, it does not integrate specific quantitative information from the state.

Quantitative classification efforts in New Hampshire have focused on single sites (Barrett 1966; Dunlop 1987; Fahey and Crow 1995; and Miller 1996) or on limited quantitative data and broad floristic patterns across the state (Sperduto 1994; Sperduto 1997). Except for Miller (1996), none of these classifications referenced bryophytes.

Miller compiled a complete flora and dendrochronological analysis of Spruce Hole Bog, Durham, New Hampshire, and quantitatively classified its plant communities. These included lagg, low shrub, *Sphagnum*/sedge lawn, tall shrub, and bog forest community types.

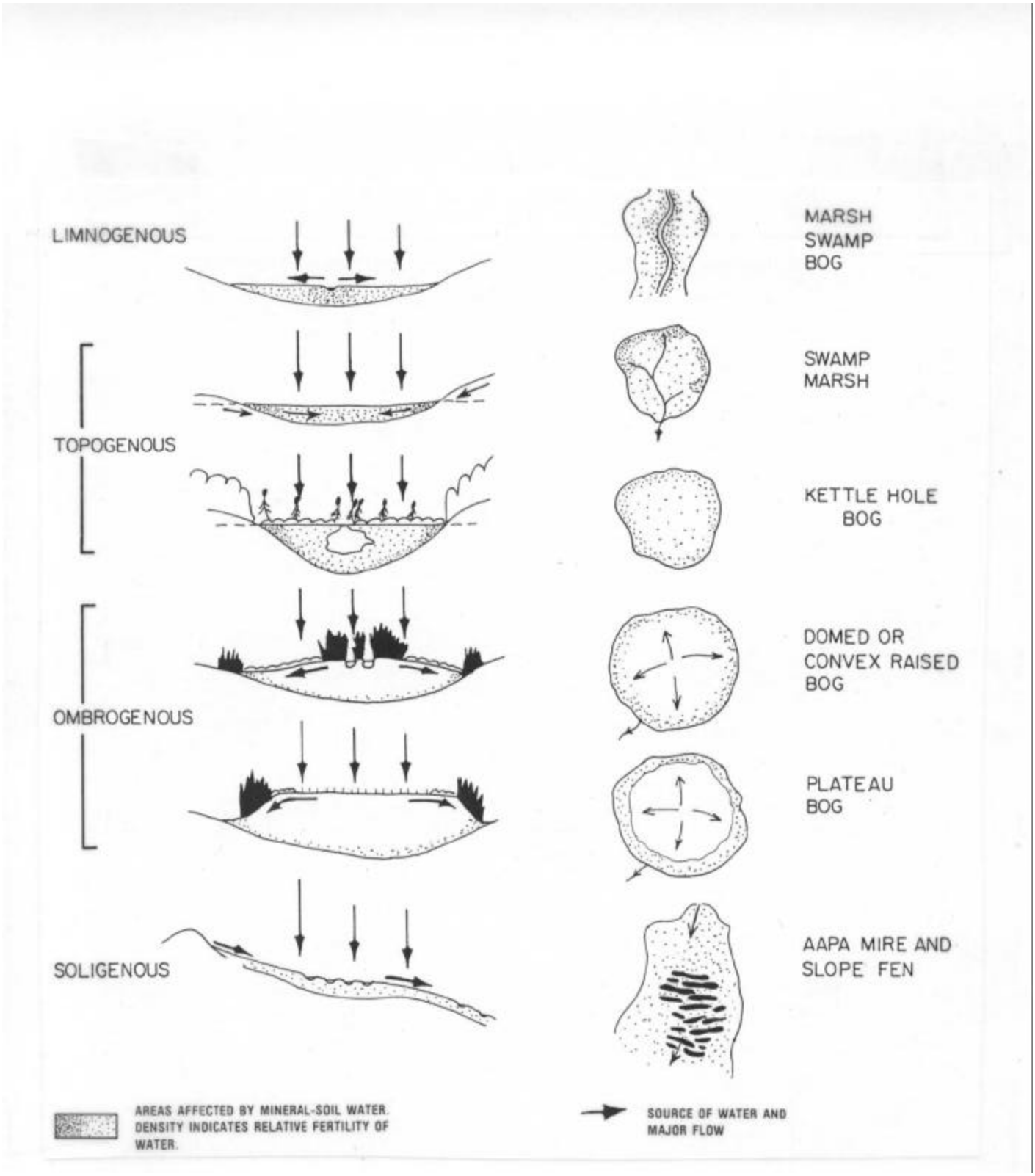

Figure 1. Major peatland landform systems (Damman and French 1987).

Dunlop (1987) documented the vascular flora at Mud Pond, Hillsborough, New Hampshire and classified the vegetation into five broad communities and seven subtypes. The *Nymphaea-Brasenia* community occurred in open water adjacent to the peatland mat. The *Chamaedaphne-Decodon-Peltandra* community occurred at the mat edge, bordering the open water. Away from the open water, the *Chamaedaphne* community consisted of three distinct subtypes in areas of consolidated peat. The *Acer-Nemopanthus* community composed wooded areas adjacent to the *Chamaedaphne* community. The moat bordering the upland supported the *Ilex verticillata-Acer-Carex canescens* community.

Fahey and Crow (1995) conducted a floristic inventory and analysis of the phytogeographic elements of the vascular flora of Pequawket Bog and Heath Pond Bog, and an analysis of the vegetation cover types at Pequawket Bog. These peatlands are both located in Ossipee, New Hampshire. At Pequawket Bog, five vegetative cover types and nine subtypes were described. The five cover types were: (1) *Nymphaea odorata*; (2) *Carex lasiocarpa*; (3) *Chamaedaphne calyculata-Woodwardia virginica*; (4) *Chamaedaphne calyculata-Vaccinium oxycoccos-Eriophorum virginicum*; and (5) *Acer rubrum-Vaccinium corymbosum-Lyonia ligustrina*.

Barrett (1966) classified vascular plant communities at Rochester Heath Bog, Rochester, New Hampshire. He described two broad community types: (1) *Carex canescens* community and (2) *Chamaedaphne calyculata* community.

Sperduto (1994, 1997) described peatland communities in New Hampshire based on limited quantitative data. These classifications emphasized different types based on climate regions and nutrients (as reflected by floristic differences) and vegetation structure classes. Sperduto and Gilman (1995) described calcareous fens and riverside seeps based on quantitative vegetation an environmental data from northern New Hampshire.

PEATLAND LANDFORM SYSTEMS

New Hampshire's peatlands are generally topogenous (fed in part by topographic runoff) or limnogenous (associated with lakes, ponds, and streams). A few peatlands in New Hampshire are soligenous (dependent on a reliable source of seepage water). No true raised, ombrogenous (rain-fed) peatlands are known in the state; however, some large peatlands in central and northern New Hampshire warrant closer examination to determine if they have such tendencies. The following framework of peatland landform systems, adapted from Damman and French (1987), was used to inform our site selection for quantitative sampling and is referenced periodically in our classification of community types. Each of the following categories are illustrated by Figures 1 and 2.

Topogenous Peatlands are influenced by upland runoff that has been in contact with mineral soil and are generally maintained by a permanent groundwater table. No or very little seasonal overbank flow enters from streams or lakes. These peatlands can be separated into two broad categories:

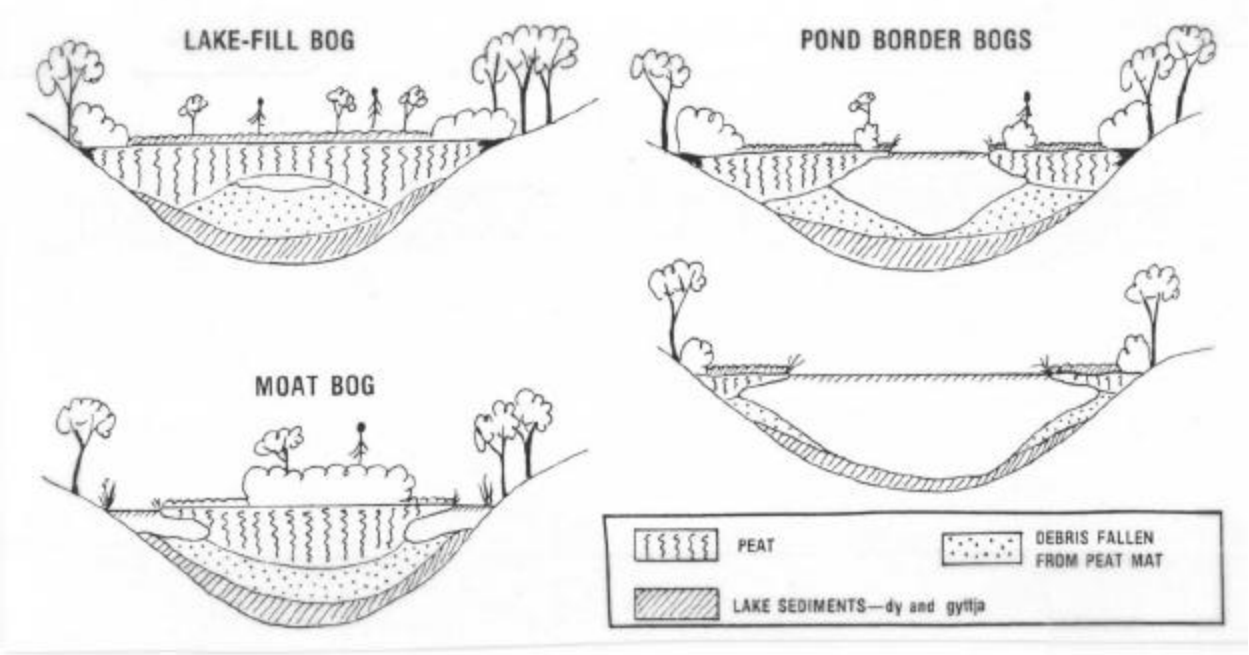

Figure 2. Types of lake-peatland systems (Damman and French 1987). While Damman and French refer to the above examples as "bogs," the term "bog" is usually applied only to ombrogenous peatlands that are rain-fed.

1. ***Lake-peatland systems*** develop in association with relatively small ponds or lakes where the lake does not flood the bog surface. The peatlands progressively fill the lake basins (hydrarch succession). Kettle holes are the classic setting for these peatlands, although this type may also occur in other lakes that have oligotrophic (see Table 2) water and no or very limited inflow or outflow from the system. Three types are recognized:
   A. *Pond-border peatlands* have a narrow to broad ring of vegetation around a remaining portion of the original waterbody. The inner margin is typically floating or quaking.
   B. *Lake-fill peatlands* have peat mats that extend across the entire lake surface, typically with at least the central portion floating or quaking.
   C. *Moat peatlands* are like lake-fill peatlands, but generally have a grounded peat mat in the center and a well-developed, water-filled moat around the peatland perimeter.

   Lake peatland systems are frequent in the state, particularly in central and southern New Hampshire where kettle holes are more abundant.
2. ***Perched water table-peatland systems*** develop in valleys, basins, and depressions with a perched water table. They are typically associated with shallow or compact till, or broad outwash and sandplain flats. They may be associated with a lake, but the lake does not control the peatland development or character as it does in lake-peatland systems or limnogenous peatlands. Upland runoff either slowly seeps through or stagnates in the peatland.

Limnogenous Peatlands are influenced by upland runoff, seasonal over-bank flow, and through-flow associated with streams or lakes. These peatlands are often associated with other types of wetlands such as emergent marshes in more seasonally flooded portions of a wetland complex, and perched-water peatland communities in areas more isolated from seasonal fluctuations. They are common throughout the state.

Soligenous Peatlands require a reliable source of seepage water entering the wetland. They are more common in northern New England where water loss from evapotranspiration is less relative to water inputs than in warmer climates. Soligenous peatlands in New Hampshire consist of a few patterned fens in the northernmost part of the state, small calcareous fens which develop on level to sloping ground with concentrated point-sources of groundwater seepage, and acidic, sloping subalpine bogs in the White Mountains.

PHYSIOGNOMIC TYPES OF PEATLANDS

There are five broad structural vegetation types described by Damman and French (1987) that are applicable to New Hampshire peatlands, most of which may be found within any one peatland system and in association with any of the landform types. To one degree or another, their compositions vary depending on the landform, nutrient regime, and climate.

1. **Forests** are typically dominated by conifers with ericaceous shrubs, and include basin swamps.

2. **Tall shrub thickets** are dominated by deciduous ericaceous shrubs and scattered tree species and include acidic and intermediate fens.

3. **Dwarf shrub peatlands** are dominated by dwarf to medium sized shrubs, and include acidic fens and intermediate fens. This structural vegetation type may be divided further into peat mats that are (a) floating or quaking or (b) solid or grounded. Other differences can be demonstrated based on species composition.

4. **Graminoid fens** are dominated by sedges and other graminoids (grasses and grass-like plants), and include acidic, intermediate, and calcareous fens.

5. **Moss carpets and mud-bottoms** are dominated by carpets of mosses, liverworts, or certain graminoids in small depressions within dwarf shrub peatlands.

"BOGS" VERSUS "FENS"

The terms "bog" and "fen" have been used in many different ways. From a long-term peatland-development perspective, the term "bog" is usually applied only to ombrogenous peatlands that are rain-fed. In this sense, New Hampshire has no known true bogs, but does contain a wide variety of "fens," or peatlands whose development is controlled in part by topogenous, limnogenous, or soligenous sources of water. Floristically, however, New Hampshire does contain peatland vegetation that is largely isolated from the influence of upland runoff, stream or lake water, or seepage, and thus is similar to vegetation that occurs in ombrogenous settings. We apply the term "bog" to plant communities that have pHs below 4.0 and only have species restricted to oligotrophic conditions. Other peatlands are considered fens.

The 4.0 cutoff was shown by Wells (1996) to be a significant and convenient cutoff in Atlantic Canada peatlands. In these peatlands, pHs of 4.0 corresponded well to specific levels of calcium, iron, nitrogen, and magnesium that marked the transition from ombrotrophic conditions of bogs to the more minerotrophic conditions of fens. Our results (see details in Results and Discussion section) are consistent with this cut-off as evidenced by the absence of species indicative of minerotrophic conditions at pHs below 4.0 in most plots. Using these terms in reference to whole-peatland sites can be misleading because many peatland basins contain both fens and bogs.

It is also important to recognize that the vegetation of bogs and fens change at different rates depending on conditions. They may be quite stable over long periods, can change slowly over long time frames as peat accumulates, or can undergo rapid change and succession over much shorter time frames in response to natural or human disturbances. For example, peatlands in lake basins or those associated with streams may be periodically flooded by beavers. Flooding can result in significant vegetation changes in peatlands, particularly if the peat mat is grounded instead of floating (Mitchell and Niering 1993). Emergent marsh and aquatic vegetation can become established where ericaceous shrubs once grew. However, over the long term water levels could change or peat build-up could resume as the basin continues to accumulate organic matter. Even kettle hole bogs, which are commonly thought to have relatively stable water levels, have been shown to exhibit broad fluctuations and corresponding changes in vegetation (Miller 1996).

NH HERITAGE ECOLOGICAL APPROACH

NATURAL COMMUNITIES

The NH Natural Heritage Inventory classifies the landscape with "natural communities," which are recurring assemblages of species found in particular physical environments. Each natural community type is distinguished by three characteristics: (1) a definite plant species composition; (2) a consistent physical structure (such as forest, shrubland, or grassland); and (3) a specific set of physical conditions (such as different combinations of nutrients, drainage, and climate conditions). Natural communities include both wetland types (e.g., red maple basin swamp) and uplands such as woodlands (e.g., rich red oak-sugar maple/ironwood talus forest/woodland) and forests (e.g., hemlock-beech-oak-pine).

While natural community names can be similar to the names of Society of American Foresters (SAF) forest cover types, natural communities are defined using a broader range of considerations. SAF forest cover types are primarily based on dominant tree species, while natural communities are based on all species, the structure of these species, and the specific physical environment. Trees are often subtle indicators of their environments. A number of natural communities can be distinguished based largely on trees, and in some cases differences in tree composition are the main difference between two community types. However, some trees are so broadly adapted that their presence does not precisely indicate site conditions (e.g., white pine or red maple), or differences in species primarily relate to cutting or other disturbances.

For example, there are four SAF spruce-fir cover types that correspond to the "montane spruce-fir forest" natural community type. These different cover types primarily relate to stand disturbance history or the successional stage rather than to major environmental differences. The four cover types also do not differentiate between upland spruce-fir forests and spruce-fir swamps. When one considers understory species and soils, upland spruce-fir forests are markedly different from the red spruce/sphagnum basin swamp natural community. In fact, the differences between these two natural communities are more dramatic than the internal differences between the four SAF spruce-fir cover types. SAF cover types are, however, useful for timber management.

Natural communities form a mosaic across the landscape, and the ecological processes in one community influence those in neighboring communities. Land managers therefore cannot consider a given natural community occurrence in isolation from its surroundings. Further, boundaries between natural community types can be either discrete (and therefore easily identified in the field) or gradual (thus making some areas difficult to map).

NATURAL COMMUNITY CLASSIFICATION

The classification of natural communities in New Hampshire is based on data from more than ten years of ecological research by ecologists with NH Heritage and The Nature Conservancy, plus extensive reviews of scientific literature. These data have been compiled and arranged into natural community types in part through the use of ordination and other statistical methods. Most state natural heritage programs continually update their classifications and cooperate with The Nature Conservancy's regional and national ecologists to ensure that natural community types are comparable across state lines.

The names of natural community types generally begin with the dominant or most characteristic plant species, and may include the name of a landscape feature or vegetative structure that is typical of that community type. For example, black gum-red maple basin swamp refers to a basin swamp (a specific landscape feature, as opposed to a streamside swamp) with black gum *and* red maple in the canopy. In addition, like all SAF forest cover types, forested natural communities may have considerable overlapping species and other characteristics, but they contain distinct and diagnostic combinations of species and physical characteristics. For example, the red spruce-northern hardwood natural community has considerably more red spruce in the overstory, and is generally higher in elevation, than the standard northern hardwood forest (sugar maple-beech-yellow birch forest natural community) despite many species that occur in both.

EXEMPLARY NATURAL COMMUNITIES

NH Heritage places particular emphasis on, and gives conservation priority to "exemplary" natural communities. Exemplary natural communities include all examples of rare types (such as a rich mesic forest) and high-quality examples of common types. High-quality sites are identified by having relatively little human impacts. These areas have greater potential to

contain or achieve natural dynamics that are characteristic of the original forests. A forested natural community need not be "old growth" to obtain exemplary status. Typical exemplary forested natural communities have a variety of characteristic species, natural regeneration within forested gaps, multiple age classes, diverse structural characteristics, abundant standing and fallen woody debris, intact soil processes, and a lack of direct evidence of human disturbance. Such characteristics can only be studied, preserved, and understood by having appropriate reference sites. Further, exemplary natural communities represent the best remaining examples of New Hampshire's flora, fauna, and underlying ecological processes.

The effects of the 1998 ice storms do not preclude any natural community from being designated exemplary. Damage caused by natural disturbances, including ice storms, blow-downs, and fire, are part the suite of natural processes influencing forest dynamics. We take heavy ice damage into account when assessing natural communities, but if the stand also displays exemplary attributes, including minimal human influence, then we are likely to classify it as such.

RARITY

NH Heritage considers the rarity of a natural community or a species both within New Hampshire and across its total range. We identify the degree of rarity within New Hampshire with a "State Rank" and throughout its range with a "Global Rank." Ranks are on a scale of 1 to 5, with a 1 indicating critical imperilment, a 3 indicating that the species is uncommon, and a 5 indicating that the species or natural community is common and demonstrably secure (see Appendix 1 for more details). Species and natural communities considered to be “globally rare” or “state rare” are those designated G1-G3 or S1-S3, respectively. Some species are rare both globally and in New Hampshire (e.g., G2 S1), while others are common elsewhere but rare in New Hampshire (e.g., G5 S1). Many communities have not been assigned global ranks at this time, pending a comprehensive review of their status and distribution range-wide.

QUALITY RANKS

In addition to considering the rarity of a natural community or species as a whole, NH Heritage ranks the quality of individual natural community occurrences and rare plant populations. These "Quality Ranks" give a more detailed picture of significance and conservation value. Quality ranks are based on the *size*, *condition*, and *landscape context* of a natural community or rare species population. These terms collectively refer to the integrity of natural processes or the degree of human disturbances that may sustain or threaten long-term survival. There are four quality ranks:

Rank Description

A Excellent Occurrence: An A-ranked natural community is a large site nearly undisturbed by humans or which has nearly recovered from early human disturbance and will continue to remain viable if protected. An A-ranked rare species occurrence is large in both area and

number of individuals, is stable, exhibits good reproduction, exists in a natural habitat, and is not subject to unmanageable threats.

B **Good Occurrence:** A B-ranked community is still recovering from early disturbance or recent light disturbance by humans and/or may be too small in size and viability to be an A-ranked occurrence. A B-ranked population of a rare species occurrence is at least stable, grows in a minimally human-disturbed habitat, and is of moderate size and number.

C **Fair Occurrence:** A C-ranked natural community is in an early stage of recovery from disturbance by humans and/or a small sized representative of the particular type of community. A C-ranked population of a rare species is in a clearly human-disturbed habitat and/or small in size and/or number, and possibly declining.

D **Poor Occurrence:** A D-ranked natural community is severely disturbed by humans, its structure and composition are greatly altered, and recovery is unlikely except in the very long term. A D-ranked occurrence of a rare species is very small, has a high likelihood of dying out or being destroyed, and exists in a highly human-disturbed and vulnerable habitat.

For example, consider a population of a rare orchid growing in a bog that has a highway running along one border. The population may be large and apparently healthy (large *size* and intact *condition*), but the long-term threats posed by disturbance at the bog's edge -- its low-quality *landscape context* (pollution from cars and roads, road-fill, garbage, altered hydrology, reduced seed dispersal, etc.) -- may reduce the population's long-term viability. Such a population of orchids would receive a lower rank than a population of equal *size* and *condition* in a bog completely surrounded by a forest (i.e., with a higher quality *landscape context*).

NH Heritage, in collaboration with other state heritage programs and The Nature Conservancy, is working to develop quality rank specifications for all of New Hampshire's natural communities and rare plant species. Unfortunately, limited time and incomplete knowledge, both on local and global scales, have prevented the development of thoroughly tested and peer reviewed quality rank specifications for most of New Hampshire's natural communities and rare species. NH Heritage expects to release quality rank specifications for open peatland natural communities in May 2000.

PROTECTING NEW HAMPSHIRE'S BIODIVERSITY

In 1994, the Northern Forest Lands Council (1994) concluded that "maintaining the region's biodiversity is important in and of itself, but also as a component of stable forest-related economies, forest health, land stewardship, and public understanding." In response to recommendations by the Northern Forest Lands Council, the NH Division of Forests & Lands and the NH Fish & Game Department established the Ecological Reserves System Project. One of the project's primary objectives was to "assess the status of biodiversity in New Hampshire and the extent to which it is protected under the current system of public and private conservation lands" (NH Ecological Reserve System Project 1998b). This question was then explored by a 28-member Scientific Advisory Group who took the question beyond the Northern

Forest and considered it in a statewide context. The conclusions of the group indicated that there was a serious need for continued biodiversity conservation in New Hampshire:

> Though conservation lands comprise approximately 20% of the land area in New Hampshire, the current system of conservation lands in New Hampshire does not appear to provide comprehensive, long-term protection of biodiversity at the species, natural community, or landscape levels. (NH Ecological Reserve System Project 1998a)

NH Heritage strives to facilitate protection of the state's biodiversity through the protection of key areas that support rare species, rare types of natural communities, and high quality examples of common natural community types. Exemplary natural communities are particularly important because we assume that if we protect an adequate number of viable examples of each natural community type, we can protect the majority of New Hampshire's species. This is sometimes referred to as a "coarse filter" approach to protecting biodiversity.

The "coarse filter" can miss important species, however, so it needs to be augmented with a finer filter. The "fine filter" approach generally focuses on specific rare species. For example, the rare, federally-threatened small whorled pogonia (*Isotria medeoloides*) occurs in a variety of second-growth hardwood forests in southern New Hampshire. This orchid's habitat may not be captured by the coarse filter approach, so we need to employ a fine filter approach (i.e., survey for the plant itself) to ensure that the species is protected.

Long-term protection of New Hampshire's species, natural communities, and ecological processes requires a variety of conservation approaches. The goal of NH Heritage's coarse and fine-filter approaches is to inform management decisions by identifying those sites that have a relatively greater potential for maintaining the natural diversity within the state.

The foundation for successful biodiversity protection is a series of representative, high-quality examples of all the state's natural community types, with their constituent species and their underlying ecological processes. The best option for this kind of protection would be a series of connected, high quality natural community types; this series would ensure that ecological processes that connect natural communities remain functionally intact within a broader landscape context. In short, there is a need for reserve areas with natural communities protected within a diverse landscape, not just in isolation.

METHODS

LANDSCAPE ANALYSIS

The first step of the inventory is a process called "landscape analysis." All available site data were examined to prioritize survey areas and to increase the efficiency of field visits in potential study areas.

Background research and landscape analysis consisted of several complementary approaches. We compiled existing information and literature on peatlands in New Hampshire and the region to determine what was known and to identify information gaps. Potential peatlands were

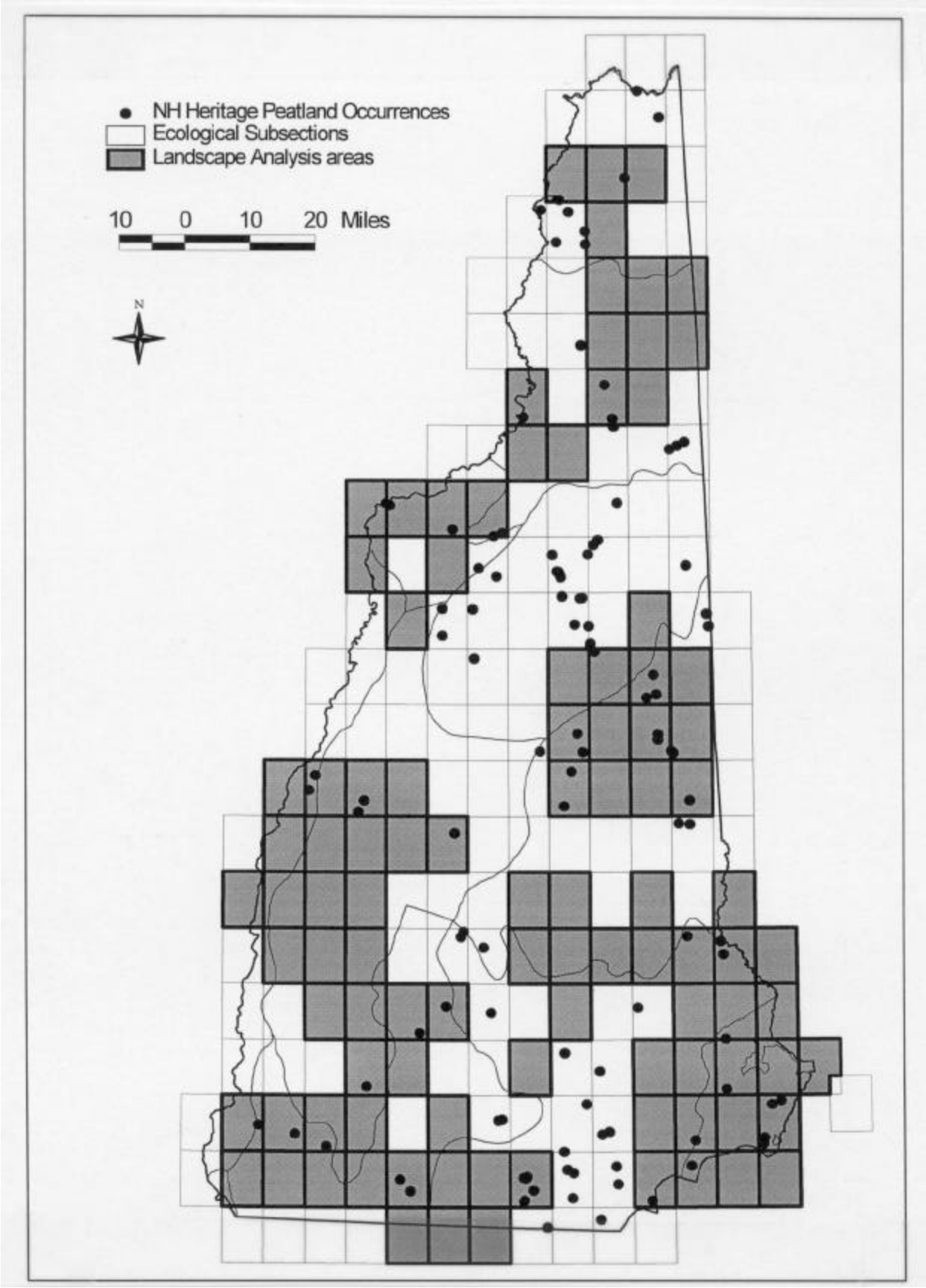

Figure 3. Distribution of Landscape analysis concentration areas. Shaded areas represent USGS topographic quadrangles that were assessed for potential open peatland sites. The black dots indicate open peatlands that were on record in the NH Heritage database when landscape analysis was conducted.

identified in all ecoregions[1] within the state (see Figure 3) by searching for appropriate landform settings, vegetation patterns, soil composition, water chemistry characteristics, and hydrologic settings. Landform settings known to support peatlands in New Hampshire and targeted during the landscape analysis process included kettle hole and lake-peatland basins, streamsides and lakesides, perched water table basins in till landscapes, and other stagnant upland or outwash basins. Source materials used for this identification included Natural Resource Conservation Service soil surveys, NH Mineral Resource Survey (White 1941), National Wetland Inventory (NWI) maps, surficial (Goldthwait 1950) and bedrock (Lyons *et al*. 1997) geological maps, U.S. Geological Survey (USGS) topographic quadrangles, and aerial photographs. Leads from knowledgeable individuals and organizations were reviewed. The NH Heritage database was also reviewed to identify the locations and quality of known peatlands and rare plants occurring in peatlands within the state. We then categorized sites within each landform setting as high, medium, or low priority for field surveys, depending on their projected likelihood of supporting exemplary peatlands. To the extent possible, we attempted to visit all major landform settings within each subsection or geographic region we considered. However, in some cases we were limited by the landform types available in a region or by the denial of landowner permission.

LANDOWNER CONTACT

NH Heritage policy dictates that we obtain landowner permission to undertake field surveys on private lands. We attempted to contact landowners of all high and medium priority study sites on private land. Land ownership was determined by consulting tax maps at town halls. Landowners were then sent a letter explaining our study, a fact sheet describing NH Heritage, and a self-addressed stamped postcard on which they could grant or deny permission for surveys.

In some instances, such as very high priority sites for which no response was received, we also attempted to contact landowners by telephone. Great care was taken to undertake field surveys only on properties for which permission was granted.

FIELD SURVEY

Field surveys were conducted at sites with the best potential to support exemplary peatlands within each landform setting for each ecoregion in New Hampshire (see Figure 4), primarily during the 1997 and 1998 field seasons. Both plot data (from specific locations) and more general site information were collected at each peatland. General information included peatland size, condition, and landscape context and surrounding natural community types, landform type, existing threats, evidence of human disturbance, and wildlife evidence.

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[1] **Ecoregions** are landscape divisions covering tens of thousands of square miles that are defined by major variations in the physical environment – particularly climate, topography, and soils – and broad distribution patterns of plants and animals (Anderson *et al*. 1999). New Hampshire lies within three ecoregions: Northern Appalachian/Boreal Forest; Lower New England/Northern Piedmont; and North Atlantic Coast.

Subsections are components of ecoregions that contain similar geologic substrates, soils, and vegetation (Anderson *et al*. 1999; Keys *et al*. 1995). They are much smaller than ecoregions, with all or portions of 10 subsections occurring within New Hampshire.

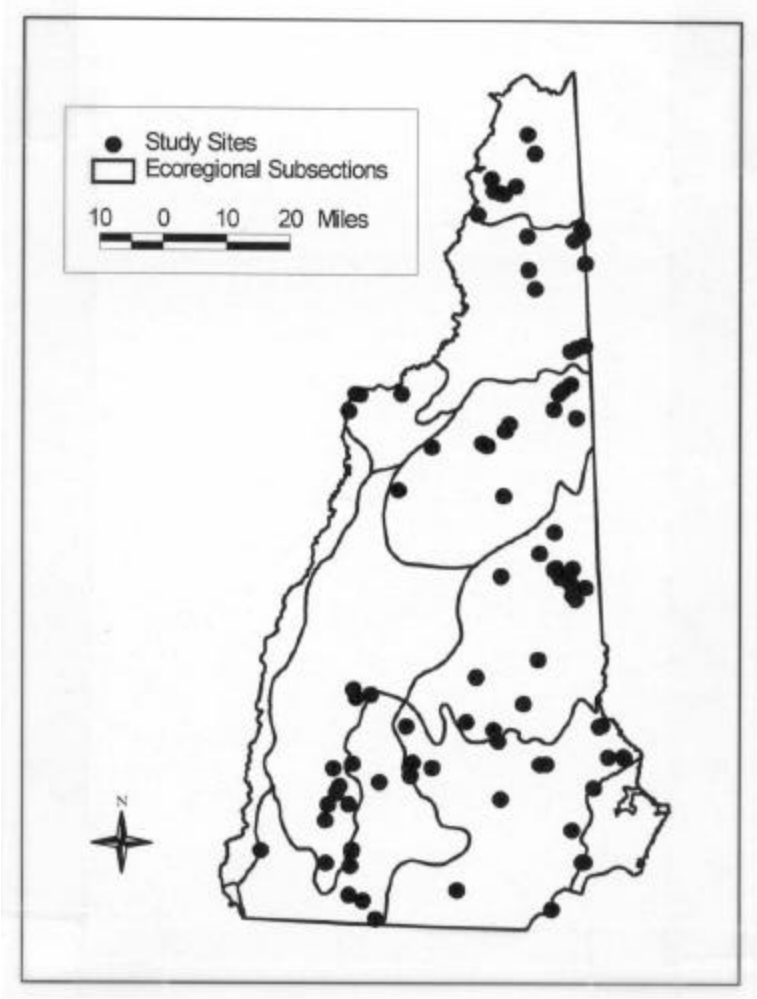

Figure 4. Distribution of peatland study sites across New Hampshire.

More detailed ecological data were collected at specific locations within each peatland. Plots were placed subjectively based on major changes in vegetation structure and composition. Most plots were 25 m^2 in size, but they occasionally ranged up to 400 m^2 depending on vegetation structure. Within each plot, the percent cover of all plant species was estimated within each strata (canopy trees, subcanopy trees, tall shrubs, medium shrubs, short shrubs, herbs, bryophytes, and lichens). We also recorded the size, condition, and landscape context for each natural community type we sampled. Most plants were identified in the field during the inventory or collected and keyed out using the resources available at NH Heritage. Vascular plant nomenclature follows Gleason and Cronquist (1991) and occasionally Fernald (1950), with common names generally following George (1997). Samples of *Sphagnum* and other bryophytes were collected from every plot and identified. Nomenclature of *Sphagnum* species follows Cleavitt *et al.* (*In press*). Soil characteristics collected at each plot included soil pH and a description of organic soil transitions using the von Post scale of peat decomposition. Micro-topography was also noted (height of hummocks or average and maximum micro-relief.)

Each site was mapped on a copy of a 1:24,000 scale USGS topographic map, and distribution maps for each peatland community type were produced using ArcView GIS version 3.1. A

Trimble GeoExplorer II Global Positioning System (GPS) was used at selected sites to determine the location of plots or peatlands and to gather natural community boundary information. The accuracy of the data collected by the GPS after differential correction was generally plus or minus 5 m. Field data and site locations of exemplary natural communities have been catalogued and mapped in the NH Heritage database.

NATURAL COMMUNITY CLASSIFICATION METHODOLOGY

To improve our understanding of peatland communities in New Hampshire, we collected plot data to represent most or all community types within each peatland complex, and we supplemented these data with existing information from the NH Heritage database. We analyzed the resulting data set using programs in PC-ORD (McCune and Mefford 1997), including Two-way Indicator Species Analysis (TWINSPAN) (based on Hill (1979a)), Detrended Correspondence Analysis (DCA) (based on Hill (1979b)), and Canonical Correspondence Analysis (CCA) (based on Ter Braak (1988)). From these analyses, we derived a classification of peatland communities in the state.

Classification attempts to cluster or divide sampling units (e.g., plots) into groups. These groups often represent different locations on a continuous gradient of change in vegetation and environmental conditions. TWINSPAN uses a polythetic divisive classification method based on reciprocal averaging (Hill 1979b) that reveals patterns of association among species and samples (plots). The results include a species-by-plots matrix that groups together plots that have similar combinations of species, and differentiates them from other groups that have dissimilar associations of species. TWINSPAN breaks any given data-set into two groups based on the strongest floristic differences in the data, and the program continues to break each resulting group into two additional groups until a specified number of separations has been achieved. It is up to the interpreter to decide where the splits lose ecological meaning and become arbitrary.

DCA ordinates species and sample plots through reciprocal averaging techniques (Hill 1979b; McCune and Mefford 1997). The graphic result is an ordination along two or more axes that reflect differences between plots and species. DCA does not force plots into groups like TWINSPAN, but does provide a graphic portrayal of how similar or different individual plots are from one another in a common "ecological space." A third technique, CCA, combines ordination with regression analyses to portray relationships of species and plots with environmental parameters (Ter Braak 1988; McCune and Mefford 1997).

These multivariate techniques have become popular in ecology, especially in the attempt to classify and ordinate large data sets into ecologically meaningful groups. They have a high utility for helping discern patterns, but they do not provide test results with statistical significance as would analysis of variance, regression, and correlation techniques.

LIMITATIONS OF STUDY

The main goal of this project was to identify high quality peatlands and to use this information to expand the NH Heritage natural community classification, to guide future conservation, and to inform management decisions. Using these guidelines, relatively large

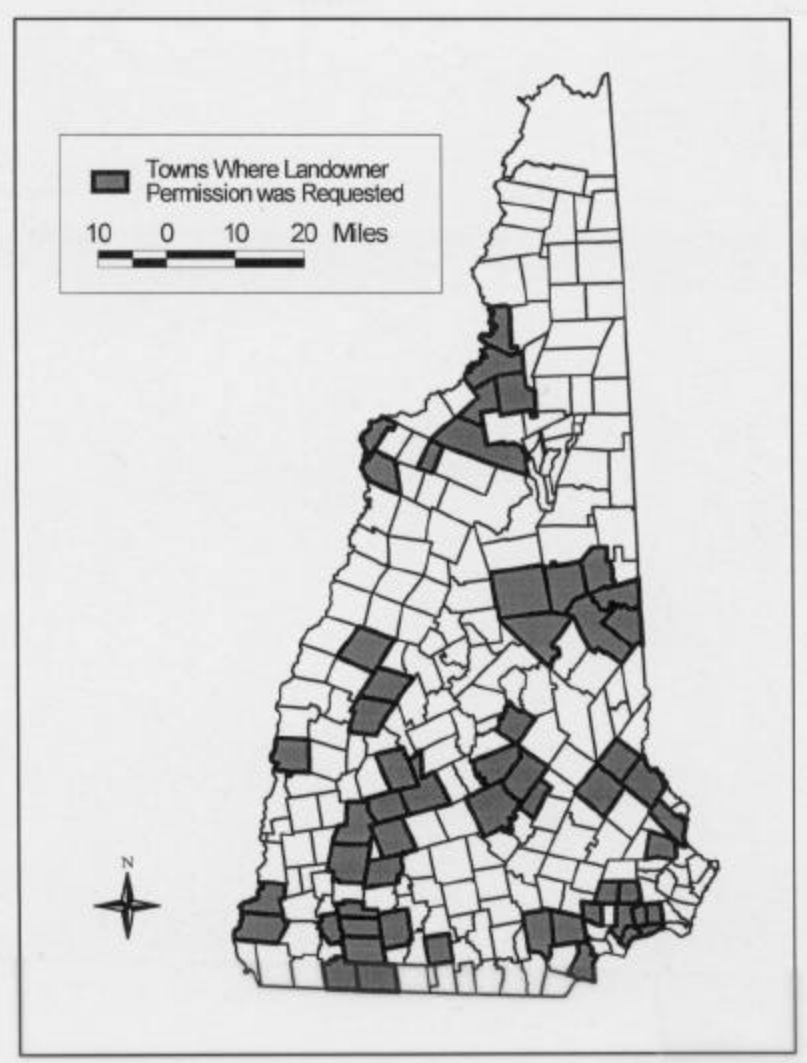

Figure 5. Distribution of towns within which NH Heritage requested permission to visit peatland sites.

peatlands were identified as potential field sites for landowner contact and subsequent fieldwork. The limitations imposed by contacting and gaining permission from landowners to investigate potential peatlands posed restrictions at some sites. It was beyond the scope of this project to identify and document all peatlands of small size or reduced quality in New Hampshire.

RESULTS AND DISCUSSION

RESULTS OF LANDOWNER CONTACT

Over the course of the study, we researched and contacted a total of 597 landowners (for 693 parcels) in 57 towns. Of the 597 landowners, 194 (32%) gave permission to visit their property, 41 (7%) refused permission, and 364 (61%) did not reply. Eighty landowners requested follow-up information. Figure 5 shows the distribution of towns within which NH Heritage requested permission to visit peatland sites.

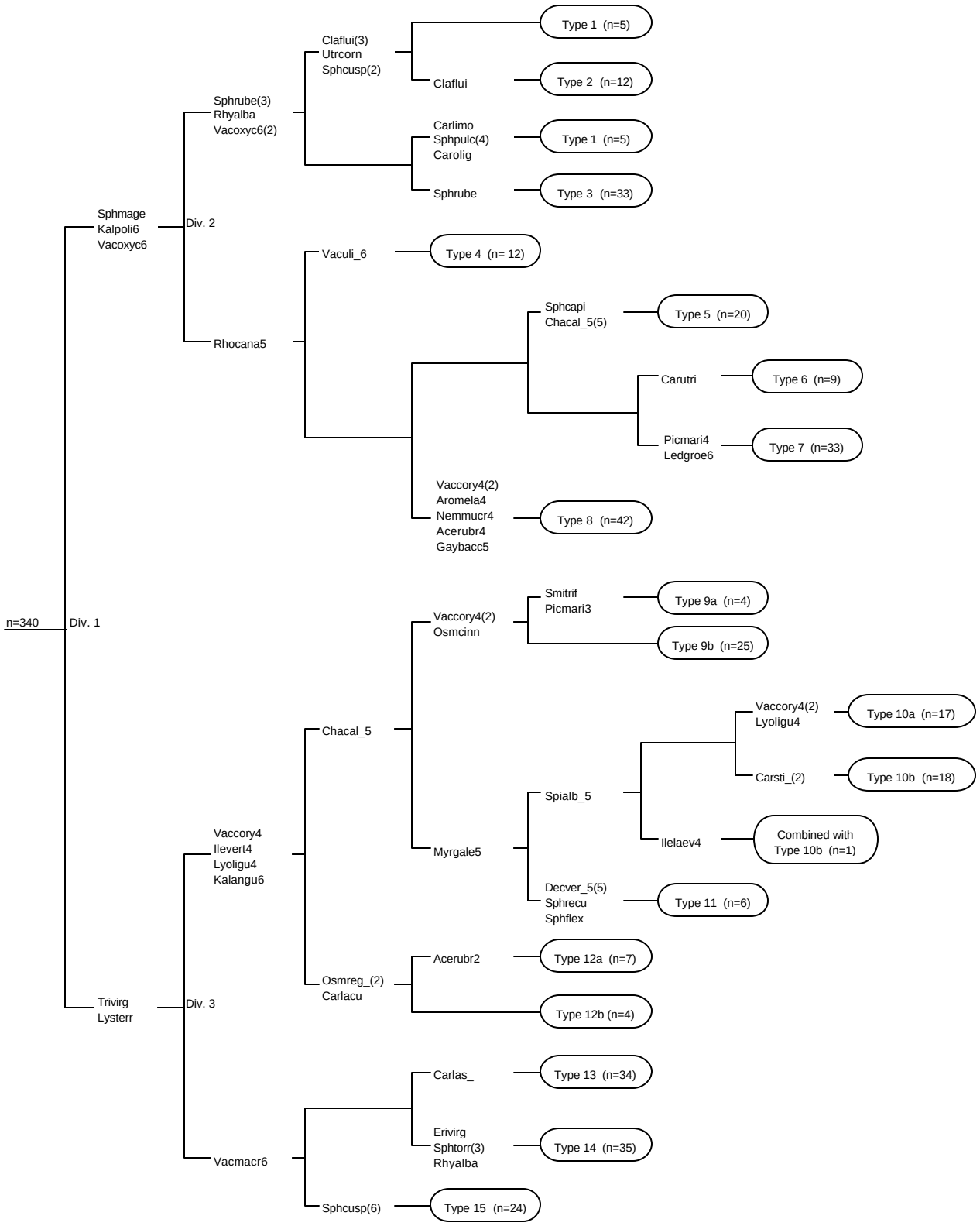

Figure 6. Dendrogram of TWINSPAN-derived types for New Hampshire peatlands with Indicator Species given for each division. Species codes are listed in Appendix 2. Community codes are defined in Table 5. Numbers in parentheses are cover class levels at which the species achieves Indicator status: 1 = <1%; 2 = 1-4%; 3 = 5-9%; 4 = 10-19%; 5 = 20-39%; 6 = 40-80%; 7 = >80%. The first 3 divisions (Div.) are indicated.

VEGETATION AND ENVIRONMENTAL CONDITIONS

Two hundred sixty-one known and potential peatland sites were documented during the statewide landscape analysis process. During the 1997 and 1998 field seasons, NH Heritage ecologists visited 76 of these sites that were identified as the most likely to support good to high quality peatlands and for which we obtained permission (Figure 4). We collected releve data at 387 plots within the 76 sites. We also recorded descriptive information at additional observation points in order to characterize the overall composition, structure, and extent of each peatland.

To classify and describe peatlands in New Hampshire, we compiled a data set of 428 releve plots, which included both the 1997-1998 field data and additional plot data from the NH Heritage database collected between 1990 and 1996. This database documents 431 vascular and non-vascular taxa that occur in New Hampshire peatlands (Appendix 2); this database, however, is not a comprehensive list of all plant species that may occur in these peatlands. Instead, it is a sub-set of vascular and non-vascular taxa that were recorded within releve plots.

DCA and TWINSPAN analyses on 428 plots revealed three groups of outliers. The first group included two circumneutral-calcareous flark plots from a single site. These plots represent a distinct community, which is described in this report but not included in the further data analysis described below. The other outliers had aquatic or emergent marsh species that were absent in the remainder of the data set. We describe two broadly defined communities based on these plots: 1) floating marshy peat mat and 2) marshy moat. These plots (n=29) were removed from subsequent TWINSPAN and DCA analyses to form a peatland data set without plots dominated by aquatic or emergent marsh species. The remaining data set consisted of 399 plots.

We describe 24 open peatland community types for the state based on TWINSPAN results and other data. We analyzed two sets of data: (1) 340 plots in which *Sphagnum* mosses and other bryophytes were collected and identified; and (2) 399 plots in which bryophytes were not identified to species. The 399 plots consisted of the first 340 plots plus an additional 59 plots of pre-existing data, for which bryophytes were summed into two broad groups (Sphagna and other bryophytes). The inclusion of pre-existing data added many plots from the White Mountain region as well as a few from other portions of the state.

Eighteen plant community types were delineated based on TWINSPAN analysis of the smaller data set (n=340 plots, Figure 6). Each community type is designated by a number (1-15) and six are also designated by an “a” or “b” to produce 18 distinct codes. Plant communities coded with the same number, but distinguished with letters, were floristically similar and were combined for the purposes of running DCA (DCA limits the number of groups portrayed at one time to 15). Type 12a corresponded to seepage swamp woodlands and is not described below because tree cover was too dense for this to be considered an open peatland type. Its counterpart, Type 12b, corresponds to open seepage marshes and is described below.

In the TWINSPAN analysis, the first division distinguished oligotrophic communities (Types 1-8) from more minerotrophic ones (Types 9-15) (Figure 6). The second division (a sub-division of Types 1-8) distinguished oligotrophic mud-bottoms and open moss lawns (Types 1-3) from oligotrophic shrub bogs and fens (Types 4-8). The third division distinguished weakly

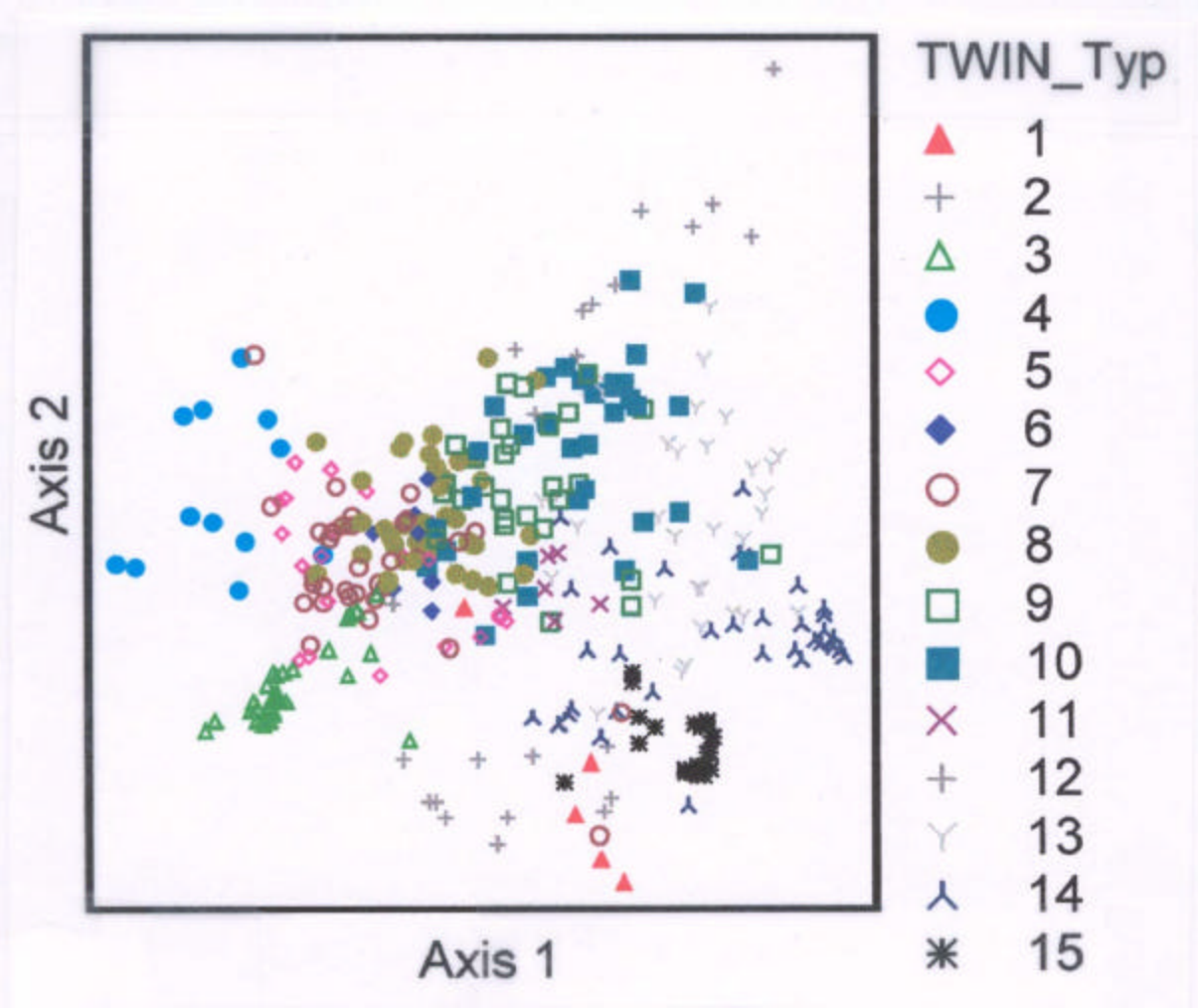

Figure 7. Detrended Correspondence Analysis (DCA) ordination graph based on 340 peatland plots in which *Sphagnum* mosses and other bryophytes were identified. TWINSPAN-defined groups are overlayed onto the ordination to portray the variation in species composition among plots among the 15 groups. Plots shown on the ordination graph are plotted in "species space," which is defined by the relative distances between plots based on their species composition and abundance. Oligotrophic communities (Types 1-8) are centered toward the left portion of the DCA graph. More minerotrophic types are centered toward the right or upper right portions of the graph. Wetter communities (e.g., *Sphagnum rubellum/Vaccinium oxycoccus* dwarf heath moss lawn) occupy the lower portion of the graph and range to the middle of the graph. Drier shrub and robust sedge fen communities occupy the middle and upper portions of the graph. The 15 "TWIN_Typ" codes correspond to community types defined in Table 5.

Table 1. Indicator species of peatland natural community types in NH. Each species is only listed in the community in which it achieved its maximum indicator value (see Appendix 3 for full table and more details). Species codes are defined in Appendix 2.

Spp. Code	Indicator Species Name
Type 1. *Sphagnum pulchrum/Carex* moss lawn	
SPHPULC	*Sphagnum pulchrum*
CARLIMO	*Carex limosa*
SCHPALU	*Scheuchzeria palustris*
AROARBU5	*Aronia arbutifolia* S2M
SPHSUBT	*Sphagnum subtile*
SPHAFFI	*Sphagnum affine*
Type 2. *Cladopodiella fluitans/Utricularia cornuta* mud-bottom	
CLAFLUI	*Cladopodiella fluitans*
UTRCORN	*Utricularia cornuta*
DROROTU	*Drosera rotundifolia*
SARPURP	*Sarracenia purpurea*
RHYALBA	*Rhynchospora alba*
CAREXIL	*Carex exilis*
DROINTE	*Drosera intermedia*
MYLANOM	*Mylia anomala*
XYRMONT	*Xyris montana*
XYRDIFF	*Xyris difformis*
CALTUBE	*Calopogon tuberosus*
ALGAE$	*algae* sp.
Type 3. *Sphagnum rubellum/Vaccinium oxycoccus* dwarf heath moss lawn	
SPHRUBE	*Sphagnum rubellum*
ERIVIRG	*Eriophorum virginicum*
VACOXYC6	*Vaccinium oxycoccos* S2D
PLABLEP	*Platanthera blephariglottis*
SPHBART	*Sphagnum bartlettianum*
SPHFLAV	*Sphagnum flavicomans*
Type 4. Oligotrophic Alpine/Subalpine bogs and subalpine heath snowbank	
all alpine natural community indicators:	
VACULI_6	*Vaccinium uliginosum* S2D
SCICESP	*Scirpus cespitosus*
EMPNIGR6	*Empetrum nigrum* S2D
SPHCAPI	*Sphagnum capillifolium*
VACVITI6	*Vaccinium vitis-idaea* S2D
RUBCHAM	*Rubus chamaemorus*
CETISLA	*Cetraria islandica*
LEDGROE6	*Ledum groenlandicum* S2D
ERIVAG_	*Eriophorum vaginatum*
SPHFUSC	*Sphagnum fuscum*
ABIBALS5 & 6	*Abies balsamea* S2M & S2D
PTICILL	*Ptillidium cilliare*
CARPAUP	*Carex paupercula*
VACOXYC6	*Vaccinium oxycoccos* S2D
DICUNDU	*Dicranum undulatum*
CARDEB_	*Carex debilis*
CARDEFL	*Carex deflexa*
CLAALPE	*Cladina alpestris*
VACBORE6	*Vaccinium boreale* S2D
CORCAND6	*Cornus candensis* S2D
BETCORD6	*Betula cordifolia* S2D
CLARANG	*Cladina rangiferina*
AROARBU4	*Aronia arbutifolia* S1
COP_GRO	*Coptis trifolia var. groenlandica*
CLIBORE	*Clintonia borealis*
CARBIGE	*Carex bigelowii*
DIALAPP	*Diapensia lapponica*
ALNVIR_4	*Alnus viridis* S1

Spp. Code	Indicator Species Name
Type 4. Oligotrophic Alpine/Subalpine bogs and subalpine heath snowbank (very acidic)	
sliding fen indicators:	
CALPICK	*Calamagrostis pickeringii*
SPHRUSS	*Sphagnum russowii*
DESFLEX	*Deschampsia flexuosa*
VACANGU6	*Vaccinium angustifolium* S2D
SPHCOMP	*Sphagnum compactum*
SPHGIRG	*Sphagnum girgensohnii*
Type 5. Chamaedaphne calyculata-Kalmia angustifolia/ Sphagnum capillifolium dwarf heath shrub bog (5)	
SPHCAPI	*Sphagnum capillifolium*
CHACAL_5	*Chamaedaphne calyculata* S2M
POLSTRI	*Polytrichum strictum*
PINRIGI5	*Pinus rigida* S2M
GEUPECK	*Geum peckii*
Type 6. Andromeda glaucophylla/Myrica gale-Carex utriculata/Sphagnum fallax fen	
ANDGLAU6	*Andromeda glaucophylla* S2D
SPHANGU	*Sphagnum angustifolium*
CAROLIG	*Carex oligosperma*
SPHFALL	*Sphagnum fallax*
KALPOLI6	*Kalmia polifolia* S2D
SMITRIF	*Smilacina trifolia*
CARUTRI	*Carex utriculata*
CARTRI_	*Carex trisperma*
BETPUMI5	*Betula pumila* S2M
Type 7. Chamaedaphne calyculata-Kalmia angustifolia/ Picea mariana dwarf heath shrub bog/very poor fen	
PICMARI4	*Picea mariana* S1
LARLARI4	*Larix laricina* S1
PICMARI5	*Picea mariana* S2M
KALANGU6	*Kalmia angustifolia* S2D
SPHMAGE	*Sphagnum magellanicum*
LARLARI6	*Larix laricina* S2D
CARPAUC	*Carex pauciflora*
CAR_BIL	*Carex trisperma var. billingsii*
GAUHISP6	*Gaultheria hispidula* S2D
SPHMAJU	*Sphagnum majus*
THUOCCI3	*Thuja occidentalis* T3
SCIHUDS	*Scirpus hudsonianus*
SPHWARN	*Sphagnum warnstorfii*
TOMNITE	*Tomenthypnum nitens*
THUOCCI5	*Thuja occidentalis* S2M
THUOCCI4	*Thuja occidentalis* S1
Type 8. Vaccinium corymbosum-Nemopanthus shrub thicket/sparse woodland	
GAYBACC5	*Gaylussacia baccata* S2M
NEMMUCR4	*Nemopanthus mucronatus* S1
PICMARI3	*Picea mariana* T3
RHOCANA5	*Rhododendron canadense* S2M
PINSTRO3	*Pinus strobus* T3
WOOVIRG	*Woodwardia virginica*
LARLARI3	*Larix laricina* T3
PINRIGI3	*Pinus rigida* T3
VACMYRT6	*Vaccinium myrtilloides* S2D

Table 1 *(continued)*. Indicator species of peatland natural community types (see Appendix 3 for details). Species codes are defined in Appendix 2.

Spp. Code	Indicator Species Name
Type 9a. Ilex verticillata/Osmunda cinnamomea/Picea tall shrub thicket/sparse woodland	
Type 9b. Ilex verticillata/Osmunda cinnamomea/ Sphagnum fallax tall-medium shrub thicket	
VACCORY4	*Vaccinium corymbosum* S1
ILEVER_4	*Ilex verticillata* S1
LYOLIGU4	*Lyonia ligustrina* S1
ACERUBR3	*Acer rubrum* T3
CARCANE	*Carex canescens*
ACERUBR4	*Acer rubrum* S1
SPHISOV	*Sphagnum isoviitae*
AROMELA4	*Aronia melanocarpa* S1
ALNINC_4	*Alnus incana* S1
BIDCERN	*Bidens cernua*
RUBHISP6	*Rubus hispidus* S2D
CAR_TRI	*Carex trisperma var. trisperma*
ACERUBR5	*Acer rubrum* S2M
SPHSUBS	*Sphagnum subsecundum*
Type 10a. Vaccinium corymbosum/Myrica gale-Spiraea alba tall-medium shrub thicket	
Type 10b. Myrica gale-Spiraea alba/Carex stricta streamside/pond border fen	
MYRGALE5	*Myrica gale* S2M
TYPLATI	*Typha latifolia*
SPHHENR	*Sphagnum henryense*
SPHFIMB	*Sphagnum fimbriatum*
CARSTI_	*Carex stricta*
SCICYPE	*Scirpus cyperinus*
CEPOCCI4	*Cephalanthus occidentalis* S1
SPHPLAT	*Sphagnum platyphyllum*
Type 11. Decodon verticillatus/Sphagnum recurvum-S. flexuosum border thicket	
SPHRECU	*Sphagnum recurvum*
DECVER_5	*Decodon verticillatus* S2M
SPHFLEX	*Sphagnum flexuosum*
HYPPALL	*Hypnum pallescens*
CALHALD	*Callicladium haldanianum*
KALLATI6	*Kalmia latifolia* S2D
DRYINTE	*Dryopteris intermedia*
BETALLE5	*Betula alleghaniensis* S2M
QUERUBR5	*Quercus rubra* S2M
Type 12a. Seepage forest/woodland	
Type 12b. Graminoid-forb-Sensitive fern seepage marsh	
OSMREG_	*Osmunda regalis*
CALCAN_	*Calamagrostis canadensis*
ONOSENS	*Onoclea sensibilis*
ACERUBR2	*Acer rubrum* T2
CARLACU	*Carex lacustris*
LYSTERR	*Lysimachia terrestris*
THEPAL_	*Thelypteris palustris*
SPIALB_5	*Spiraea alba* S2M
ASTUMBE	*Aster umbellatus*
MAICANA	*Maianthemum canadense*
ABIBALS3	*Abies balsamea* T3
GALTINC	*Galium tinctorium*
LYCUNIF	*Lycopus uniflorus*
BETPOPU3	*Betula populifolia* T3
OSMCINN	*Osmunda cinnamomea*
ABIBALS4	*Abies balsamea* S1
SALLUC_5	*Salix lucida* S2M

Spp. Code	Indicator Species Name
Type 12a. Seepage forest/woodland	
Type 12b. Graminoid-forb-Sensitive fern seepage marsh *continued*	
ARANUDI	*Aralia nudicaulis*
MNIUM$	*Mnium* sp.
GALASPR	*Galium asprellum*
CHEGLAB	*Chelone glabra*
UVUSESS	*Uvularia sessilifolia*
FRANIGR3	*Fraxinus nigra* T3
THAPUBE	*Thalictrum pubescens*
TOXVERN4	*Toxicodendron vernix* S1
CALLPAL	*Calla palustris*
SYMFOET	*Symplocarpus foetidus*
HYDAMER	*Hydrocotyle americana*
EQUFLUV	*Equisetum fluviatile*
EUPATO$	*Eupatorium* sp.
MENARV_	*Mentha arvensis*
RUBPUBE	*Rubus pubescens*
VIBLENT4	*Viburnum lentago* S1
FRANIGR4	*Fraxinus nigra* S1
CARBROM	*Carex bromoides*
CAMAPAR	*Campanula aparinoides*
SPHTERE	*Sphagnum teres*
SCILONG	*Scirpus longii*
Type 13. Carex lasiocarpa/Myrica gale-Vaccinium macrocarpon sedge fen	
CARLAS_	*Carex lasiocarpa*
SPHLESC	*Sphagnum lescurii*
VACMACR6	*Vaccinium macrocarpon* S2D
SAGLATI	*Sagittaria latifolia*
CEPOCCI5	*Cephalanthus occidentalis* S2M
CARUTRI	*Carex utriculata*
TRIVIRG	*Triadenum virginicum*
SPITOME5	*Spiraea tomentosa* S2M
PELVIRG	*Peltandra virginica*
Type 14. Sphagnum torreyanum/Vaccinium macrocarpon/ Rhyncospora alba moss lawn	
SPHTORR	*Sphagnum torreyanum*
DULARUN	*Dulichium arundinaceum*
SPHPAPI	*Sphagnum papillosum*
SPHPALU	*Sphagnum palustre*
SOLPURS	*Solidago purshii*
Type 15. Sphagnum cuspidatum/ Vaccinium macrocarpon moss lawn	
SPHCUSP	*Sphagnum cuspidatum*
JUNPELO	*Juncus pelocarpus*
CARBULL	*Carex bullata*

minerotrophic to minerotrophic tall and medium shrub types (Types 9-12) from weakly minerotrophic to minerotrophic moss lawns and sedge/shrub fens (Types 13-15). Remaining divisions are detailed in Figure 6, with TWINSPAN indicator species outlined for each division.

We ran Indicator Species Analysis to identify the indicator value of each species with respect to each of the 15 community types or pairs of community types (Table 1 and Appendix 3). The indicator value integrates a species' fidelity to and frequency and abundance within a community type into a single index. We arranged the species in the Indicator Species Analysis table by community type, listing each species under the community type in which it achieved the highest indicator value in the data set. We removed species that had indicator values of less than 10, with the exception of Sphagna and several rare plants. In the case of Types 12a and 12b (seepage peatlands), we removed all species with indicator values less than 18, which included species restricted to, but infrequent within, Types 12a or 12b. Species with very high or maximum indicator values in two types are repeated in the table under each type to indicate their importance in both.

DCA revealed some of the major differences among peatland types (Figure 6). Oligotrophic communities (Types 1-8) are centered toward the left portion of the DCA graph. More minerotrophic types are centered toward the right or upper right portions of the graph. Wetter communities (e.g., saturated moss lawns with low dwarf heaths) occupy the lower portion of the graph and range to the middle of the graph. Drier shrub and robust sedge fen communities occupy the middle and upper portions of the graph.

CCA results were used to inform our understanding of the environmental differences among types but are not presented here. We found that pH, height and density of the medium-dwarf shrub layer, micro-relief, degree of decomposition near the surface, and types and the presence or absence of tall shrubs were all important variables in identifying differences among community types. A sparse or absent dwarf shrub layer was associated with wetter conditions, while height and density of shrubs increased with higher pHs or drier conditions. Tall shrubs and sedge-dominated fens were associated with more minerotrophic conditions.

In our analysis of the larger data set (n=399 plots), we scrutinized the TWINSPAN vegetation table and other outputs for distinct groups consisting primarily of plots not analyzed in the smaller data set. Two major groups emerged that were not apparent in the smaller (n=340) data set. The first included a large number of alpine plots (n=60), including 12 from the smaller data set. TWINSPAN indicator species for this group were *Vaccinium uliginosum* var. *alpinum* (bilberry)*, *Empetrum nigrum* (black crowberry)*, and *Ledum groenlandicum* (Labrador-tea). Within this subset of plots, three distinct groups were defined: (1) steeply sloped fens on tops of alpine cliffs characterized by abundant *Calamagrostis pickeringii* (Pickering's reed bent-grass)*; (2) wet alpine/subalpine bogs characterized by bog species indicative of saturated conditions; and (3) wooded subalpine snowbank or bog-margin peatlands with fewer wet-site species.

The second distinct group evident in the larger data set included montane fens from the White Mountains characterized by *Calamagrostis pickeringii* (Pickering's reed bent-grass)*. These peatlands were distinguished by the presence of this and other montane species uncommon or absent in the remainder of the data set. All other plots in the larger data set

(n=399 plots) aligned closely with plots from the smaller data set in groups that corresponded to one of the 15 types described above.

Calcareous fen descriptions adapted from Sperduto and Gilman (1995) are included in this report in order to present a comprehensive classification of open peatlands in the state. The seepage marsh description was based on the four plots in this data set and additional information from other sources. Montane heath woodlands descriptions from Sperduto and Cogbill (1999) have been modified in this report based on additional data from mid-elevation occurrences.

All types described by Barrett (1966), Dunlop (1987), Fahey and Crow (1995), and Miller (1996) appeared to correspond well to one of the community types described in this report. However, the lack of *Sphagnum* moss data from most of these studies limited the precise classification of some groups.

TROPHIC REGIME AND PH

For the purposes of this document, the trophic levels and the approximate corresponding pH divisions outlined in Table 2 are used to group community types within each broad physiognomic category. Nutrient trophic regimes in New Hampshire peatlands range from oligotrophic to minerotrophic, roughly matching a pH scale from very acidic to calcareous. Oligotrophic peatlands are very low in productivity, low in nutrient availability (usually low base-cation levels), and thus acidic or very acidic. In contrast, minerotrophic peatlands tend to have higher productivity, higher nutrient availability (usually higher base-cation content), and thus circumneutral or calcareous pHs. However, it is important to note that pH level is not perfectly linked to productivity or trophic level because of the influence other factors, such as hydrologic regime. For instance, given a certain pH level, a community with a saturated flood regime will be less productive than one with a temporarily flooded flood regime. In this case, increased wetness decreases productivity through its effect on temperature, oxygen levels and ultimately decomposition rates that control nutrient availability. Further, while high pHs imply high base-cation content, they do not necessarily indicate a high availability level for all nutrients. While base-cations are in short supply in very acidic soils, aluminum levels can be high enough to have a toxic effect on some plants. Finally, pH and trophic regime can vary dramatically at a fine scale within a peatland from hummock to hollow.

Table 2. Trophic levels and approximate corresponding pH ranges in New Hampshire peatland community types.

Trophic Level	Relative Acidity	Approximate pH Range
Oligotrophic	Very acidic	<4
	Acidic	4-5
Weakly minerotrophic	Acidic	4-5
Intermediate	Acidic	4-5
	Subneutral	5-6
Minerotrophic	Circumneutral	6-7.3
	Calcareous	>7.3

Type	Total Plots	Depth - von Post H5 (cm)			von Post at 20 cm (H_)			% Fibric/Hemic Top 1 m			Min Peat Depth (cm)		
		Avg	SD	n	Avg	SD	n	Avg	SD	n	Avg	SD	n
1	5	100.0		1	1.7	0.8	3	100.0	0.0	4	157.5	136.7	4
2	12	60.0		1	2.6	0.7	11	96.0	12.6	10	105.0	49.5	12
3	35	55.0	25.2	7	2.4	0.8	30	87.4	24.2	25	146.4	117.4	33
4	12			0	1.5	0.0	2			0	55.0	37.1	9
5	20	41.7	30.3	18	4.1	2.3	18	44.7	32.3	19	131.8	69.2	19
6	9	43.3	26.0	6	2.8	2.0	8	51.4	32.0	7	118.9	92.7	9
7	33	52.9	30.5	22	2.5	1.5	32	65.1	33.1	30	167.3	124.0	31
8	42	34.1	27.5	32	4.2	1.9	39	46.0	35.7	39	142.3	86.7	40
9	29	22.3	25.1	24	6.0	2.4	28	22.6	28.5	28	150.3	99.1	29
10	35	21.3	20.2	22	5.6	2.2	27	32.3	35.9	30	126.9	93.7	30
11	5	11.7	10.4	3	4.1	1.5	4	33.8	45.0	4	81.3	41.9	4
12	11	17.5	9.6	4	7.6	1.3	5	14.0	11.4	5	54.2	45.9	6
13	33	27.7	16.5	22	4.0	2.2	28	48.7	36.1	31	134.9	119.3	32
14	35	24.7	19.4	25	4.0	1.6	32	42.9	36.8	33	99.9	84.5	34
15	24	24.9	13.3	16	3.4	1.1	22	50.0	37.7	24	88.7	39.2	24

Type	Total Plots	S2 Height (m)			Hummock/Hollow %			Avg Hummock Hgt (cm)			Max Hummock Hgt (cm)		
		Avg	SD	n	Avg	SD	n	Avg	SD	n	Avg	SD	n
1	5	0.30	0.05	3	75.0		1	10.0		1	15.0		1
2	12	0.15	0.05	11	16.9	23.7	9	10.5	4.5	6	13.8	5.4	5
3	35	0.29	0.22	35	24.9	26.7	26	13.1	7.7	24	21.0	11.3	22
4	12	0.16	0.09	7	68.8	7.5	4	18.8	7.8	4	36.9	13.0	4
5	20	0.52	0.27	19	54.4	23.9	18	24.2	10.6	17	39.7	15.4	17
6	9	0.49	0.36	7	42.9	22.4	6	16.6	6.2	6	23.3	8.8	6
7	33	0.48	0.29	31	45.5	23.3	28	21.8	7.8	29	35.7	12.2	29
8	42	0.85	0.30	36	53.9	16.8	39	25.7	8.9	39	41.5	12.3	39
9	29	0.84	0.29	26	46.3	16.5	28	22.9	5.8	28	45.0	9.5	28
10	35	0.88	0.25	30	47.8	23.0	30	24.6	8.7	29	44.7	16.9	30
11	5	0.95	0.25	4	38.8	30.1	4	25.0	5.0	3	48.3	10.4	3
12	11	1.18	0.77	4	52.0	8.4	5	38.8	7.5	4	48.3	12.6	3
13	33	0.67	0.27	27	33.0	25.8	22	18.8	9.6	20	27.8	13.1	21
14	35	0.42	0.27	33	25.5	29.4	31	14.2	7.7	21	29.2	16.9	21
15	24	0.29	0.24	22	21.0	31.2	22	10.6	7.7	13	19.9	12.3	12

Type	Total Plots	Elevation (ft)			Soil pH			Conductivity (uS/cm)		
		Avg	SD	n	Avg	SD	n	Avg	SD	n
1	5	1141.2	249.6	5	4.0	0.2	4	40.3	2.1	3
2	12	996.8	656.5	12	3.9	0.3	9	74.1	40.2	5
3	35	779.3	369.0	35	3.9	0.3	30	84.4	33.5	20
4	12	3730.4	413.7	12	3.8	0.3	4	47.8	25.7	4
5	20	642.1	714.1	20	3.8	0.3	17	130.9	173.1	9
6	9	441.1	209.3	9	4.1	0.2	8	48.5	15.3	4
7	33	1106.1	713.4	33	3.9	0.6	27	75.3	58.9	21
8	42	537.4	329.8	42	3.9	0.4	38	71.8	43.5	26
9	29	554.2	355.3	29	4.4	0.4	28	69.5	53.3	21
10	35	826.7	406.9	35	4.5	0.6	31	77.8	58.6	20
11	5	793.4	392.4	5	4.4	0.7	4	61.0	45.1	4
12	11	395.0	53.1	11	5.3	0.6	10	66.3	20.6	8
13	33	708.4	435.6	33	4.9	0.6	30	104.4	77.7	16
14	35	1206.7	419.9	35	4.3	0.4	34	55.6	36.0	30
15	24	961.5	347.0	24	4.2	0.3	22	84.5	49.7	19

Table 3. Environmental attributes averaged for each TWINSPAN-defined peatland vegetation type. “Type” codes are defined in Table 5. “Total Plots” indicates the total number of plots in which data regarding each peatland type were gathered. “n” indicates the number of plots in which data regarding each environmental attribute were gathered.

Type	Total Plots	Non-Vascular (N)		Herb Layer (H)		Dwarf Shrub Layer (S2D)		Medium Shrub Layer (S2M)	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD
1	5	96.1	4.0	7.7	4.9	3.4	3.0	4.4	5.4
2	12	100.1	25.1	23.0	27.0	4.9	3.0	4.7	6.3
3	35	97.9	4.1	6.0	6.6	6.0	3.9	9.1	9.2
4	12	91.5	19.6	21.4	20.5	26.9	19.4	3.4	7.1
5	20	87.1	11.6	2.7	8.2	6.3	8.4	37.9	21.8
6	9	92.9	8.5	12.4	11.7	10.0	14.1	31.2	26.0
7	33	94.1	7.7	5.9	5.5	9.9	10.4	18.0	11.9
8	42	73.7	27.9	7.4	14.3	5.8	7.1	28.6	19.2
9	29	77.1	20.4	11.8	9.6	1.9	2.4	9.9	11.0
10	35	48.1	33.4	13.2	12.0	1.2	2.7	25.1	19.3
11	5	74.4	35.8	4.0	6.2	1.4	2.0	27.8	16.5
12	11	24.2	31.1	70.4	27.5	0.5	0.7	9.5	9.9
13	33	35.4	37.4	20.2	16.6	6.3	12.0	16.5	16.4
14	35	86.2	18.9	12.7	10.4	3.5	6.2	11.9	14.7
15	24	80.5	28.4	10.8	10.4	4.7	8.3	8.2	16.7

Type	Total Plots	S2 combined (S2M + S2D)		Tall Shrub Layer (S1)		Subcanopy Tree Layer (T3)		Canopy Tree Layer (T2)	
		Avg	SD	Avg	SD	Avg	SD	Avg	SD
1	5	7.7	7.8	0.1	0.1	0.0	0.0	0.0	0.0
2	12	9.5	7.3	0.0	0.0	0.0	0.0	0.0	0.0
3	35	15.0	9.0	0.5	1.3	0.0	0.0	0.0	0.0
4	12	30.2	23.8	5.1	9.8	0.0	0.0	0.0	0.0
5	20	44.2	21.7	1.5	2.7	0.2	0.7	0.0	0.1
6	9	41.2	23.1	0.1	0.2	0.3	0.6	0.7	1.7
7	33	27.8	14.4	5.7	7.4	2.9	4.6	0.1	0.4
8	42	34.4	20.3	15.1	12.9	6.1	8.1	1.6	4.0
9	29	11.8	10.8	26.1	15.1	4.2	4.1	1.2	3.3
10	35	26.3	19.6	10.4	17.1	1.3	2.0	1.5	5.3
11	5	29.2	16.9	3.6	3.1	0.3	0.6	0.0	0.0
12	11	9.9	10.1	15.6	14.5	10.0	10.2	10.9	13.8
13	33	22.8	16.8	0.4	0.9	0.0	0.2	0.0	0.0
14	35	15.4	14.3	0.2	0.5	0.0	0.1	0.0	0.0
15	24	12.9	18.1	0.1	0.1	0.0	0.0	0.0	0.0

Table 4. Average percent cover by strata for each TWINSPAN-defined peatland vegetation type. "Type" codes are defined in Table 5.

DESCRIPTIONS OF NATURAL COMMUNITY TYPES AND VARIANTS

In the descriptions below, the primary distinguishing features are given for each community type, including relevant floristic differences, vegetation structure, and environmental characteristics. Averages and standard deviations for environmental attributes and vegetation cover by strata are presented in Tables 3 and 4. A general rule of thumb for interpreting standard deviations (assuming that they are normally distributed around the mean) is that approximately 67% of all measurements will fall within plus or minus one standard deviation on either side of the average, and 95% will fall within plus or minus two standard deviations.

For each community type, the community name is followed by the TWINSPAN group number in parentheses. Rare plant species that may be present are indicated with an asterisk (*).

The level of peat decomposition in each community is described with the qualitative von Post scale. Peat is considered to be moderately well decomposed if its von Post value is near the middle of this scale (ca. H5), well decomposed if closer to H10, and poorly decomposed if closer to H1. Degrees of decomposition are specified by depth range in the descriptions (e.g., "soils are poorly decomposed within the upper 0.5 m of peat") and detailed further in Table 3.

Table 5. Table of TWINSPAN-defined communities, with TWINSPAN-codes and type numbers.

Community Type #	TWINSPAN Code	Community Name
Type 1	1_Spulch	*Sphagnum pulchrum/Carex* moss lawn (1)
Type 2	2_Mudbot	*Cladopodiella fluitans/Utricularia cornuta* mudbottom (2)
Type 3	3_SrubOxy	*Sphagnum rubellum/Vaccinium oxycoccus* dwarf heath moss lawn (3)
Type 4	4_Alpine	Oligotrophic alpine/subalpine bogs and subalpine heath snowbank (very acidic) (4)
Type 5	5_AcDwM	*Chamaedaphne calyculata-Kalmia angustifolia/Sphagnum capillifolium* dwarf heath shrub bog (5)
Type 6	6_CxMs	*Andromeda glaucophylla-Myrica gale/Carex utriculata/Sphagnum fallax* fen (6)
Type 7	7_ChamBkS	*Chamaedaphne calyculata-Kalmia angustifolia/Picea mariana* dwarf heath shrub bog/very poor fen (7)
Type 8	8_VacNem	*Vaccinium corymbosum-Nemopanthus* shrub thicket/sparse woodland (8)
Type 9a	9_IlexTs	*Ilex verticillata/Osmunda cinnamomea/Picea* tall shrub thicket/sparse woodland (9a)
Type 9b		*Ilex verticillata/Osmunda cinnamomea/Sphagnum fallax* tall-medium shrub thicket (9b)
Type 10a	10_MyCx	*Vaccinium corymbosum/Myrica gale-Spiraea alba* tall-medium shrub thicket (10a)
Type 10b		*Myrica gale-Spiraea alba/Carex stricta* streamside/pond border fen (10b)
Type 11	11_DecSp	*Decodon verticillatus/Sphagnum recurvum-S. flexuosum* border thicket (11)
Type 12a	no code	Seepage forest/woodland (12a)
Type 12b	12_SeepM	Graminoid-forb-sensitive fern seepage marsh (12b)
Type 13	13_Cxlas	*Carex lasiocarpa/Myrica gale-Vaccinium macrocarpon* sedge fen (13)
Type 14	14_Storr	*Sphagnum torreyanum/Vaccinium macrocarpon/Rhyncospora alba* moss lawn (14)
Type 15	15_Scusp	*Sphagnum cuspidatum/Vaccinium macrocarpon* moss lawn (15)
Type 16	16_CircFlrk	Circumneutral-calcareous flark (16)
Type 17	17_Marsh	Emergent marsh
Type 18	18_Aqmot	Marshy moat (18)
Type 19	19_Pond	Pond or lake community
Type 20	20_Stream	Stream community
Type 21	21_Kettl	Kettle hole pond community
Type 22	22_AlnSp	Alder thicket (undifferentiated)
Type 23	23_MarPt	Floating marshy peat mat (23)
Type 24a	no code	Montane heath shrub thicket/sparse woodland
Type 24b		Montane alder-heath shrub thicket
Type 25	25_Cpick	Montane *Calamagrostis pickeringii*/shrub level/sloping fen (25)
Type 26	26_CalFen	Calcareous sedge/moss fen (26)
Type 27	27_ThujaSW	*Thuja occidentalis* circumneutral string (27)

The shrub layer is divided into three height categories: dwarf, medium, and tall. The dwarf shrub layer has an average shrub height of less than 0.5 m, which may include shrub species that never exceed 0.5 m and those that are limited to this height in a particular community type. The medium shrub layer ranges in height from 0.5-1.5 m. The tall shrub layer is generally taller than 1.5 m.

Natural community names and groups are concisely displayed in the Summary on page iv.

MUD-BOTTOMS, OPEN MOSS LAWNS, AND FLARKS

The following natural communities are saturated open *Sphagnum* moss, liverwort, or other non-vascular plant dominated lawns or carpets with a sparse, dwarf heath shrub layer. Heath shrubs average less than 15% cover and are less than 0.5 m in height in all communities, although there is some variation among individual plots. Peat is usually poorly decomposed near the surface and hummocks are weakly developed (average height is less than 0.15 m in all communities). *Rhynchospora alba* (white beak-rush) is occasional to frequent in all communities, and peat mosses are usually dominant.

Mud-bottom and open moss lawn communities can be divided into oligotrophic (very acidic), weakly minerotrophic, and minerotrophic communities. The more oligotrophic communities are indicated by *Vaccinium oxycoccos* (small cranberry), *Sphagnum rubellum*, and low pHs (<4.0). The weakly minerotrophic communities are indicated by some combination of *Myrica gale* (sweet gale), *Vaccinium macrocarpon* (large cranberry), *Carex canescens* (silvery sedge), *Triadenum virginicum* (marsh St. John's-wort), *Dulichium arundinaceum* (three-way sedge), and pHs between 4.0 and 5.0. Minerotrophic communities are indicated by calciphytic plants, such as *Scirpus hudsonianus* (northern cotton club rush), *Carex livida* (livid sedge), *Carex tenuiflora* (thin-flowered sedge), *Muhlenbergia glomerata* (clustered marsh muhly), and *Sphagnum contortum*, and pHs above 5.5. These indicators may only be present in low abundance.

Distribution maps are presented in Appendix 5. Photographs are displayed in Appendix 6.

OLIGOTROPHIC TYPES (VERY ACIDIC)

The following two communities are most common in kettle holes or portions of other peatland basins that are isolated from the minerotrophic influence of upland runoff or lake water.

***Cladopodiella fluitans/Utricularia cornuta* mud-bottom (2)**

Mud-bottoms are wet, oligotrophic lawns dominated by low, turfy mats of the leafy liverwort *Cladopodiella fluitans*, which turns black and looks like mud from a distance. *Sphagnum cuspidatum*, *Utricularia cornuta* (horned bladderwort), *Rhynchospora alba* (white beak-rush), and *Drosera intermedia* (spatulate-leaved sundew) are also diagnostic and usually present in abundance. Dwarf shrubs are stunted (usually <0.2 m) and often contribute less than 8% cover; *Vaccinium oxycoccos* (small cranberry), *Andromeda glaucophylla* (bog rosemary), and *Chamaedaphne calyculata* (leather-leaf) are the most frequent shrub species. Species characteristic of this community, but that also occur on other oligotrophic dwarf shrub peatlands, include *Sphagnum rubellum*, *S. magellanicum*, *Sarracenia purpurea* (pitcher-plant), and *Drosera*

rotundifolia (round-leaved sundew). North of the White Mountains, *Carex exilis* (meagre sedge)* may be abundant in this community. Mud-bottoms with *Carex exilis* can be the dominant community in the wet "flarks" of patterned fens between linear "strings" characterized by *Picea mariana* (black spruce) and heath shrubs. Trees and tall shrubs are always absent in this community.

In this community, peat is typically poorly decomposed near the surface and has a relatively flat surface profile (hummocks are generally <0.20 m; average hummock height is 0.10 m). The average height of dwarf heath shrubs is 0.15 m, and pHs are very acidic, averaging 3.9. Mud-bottoms generally occur in association with floating or grounded peat mats of pond-border or lake-fill kettle holes, frequently in association with shallow peat mats near interior pools. This community type is broadly distributed in New Hampshire, but it is concentrated in the central and southern portions of the state where kettle holes are more abundant.

***Sphagnum rubellum/Vaccinium oxycoccus* dwarf heath moss lawn (3)**

This community includes floating and grounded peat mats dominated by *Sphagnum rubellum* and a relatively sparse and dwarfed heath shrub layer (average shrub height is 0.29 m and cover is generally 5-20%). *Vaccinium oxycoccos* (small cranberry) is diagnostic and prominent despite its diminutive stature. *Chamaedaphne calyculata* (leather-leaf) is also always present, and *Kalmia polifolia* (bog laurel), *Kalmia angustifolia* (sheep laurel), *Andromeda glaucophylla* (bog rosemary), *Sarracenia purpurea* (pitcher-plant), *Rhynchospora alba* (white beak-rush), and *Eriophorum virginicum* (tawny cotton-grass) are often present. *Eriophorum vaginatum* var. *spissum* (hare's-tail) is occasional. A fairly distinct variant of this community is evident, characterized by an abundance of *Sphagnum magellanicum* and less frequent *Drosera rotundifolia* (round-leaved sundew). The rare *Gaylussacia dumosa* var. *bigeloviana* (huckleberry)* occurs in examples within ca. 30 miles of the coast. Trees are absent or sparse and stunted.

This community is widespread throughout the state in oligotrophic kettle holes and other peatland basins that are isolated from the minerotrophic influence of upland runoff or lake water. Average pH is 3.9, peat is poorly decomposed in the upper 0.5 meter, and hummock-hollow topography is poorly developed (average hummock height 0.13 m).

OLIGOTROPHIC – WEAKLY MINEROTROPHIC TYPES (ACIDIC)

Oligotrophic to weakly minerotrophic moss lawns can usually be distinguished from other moss lawns and mud-bottoms by the absence or low abundance of *Sphagnum rubellum* and *Vaccinium oxycoccos* (small cranberry), the presence of aquatic Sphagna (*Sphagnum pulchrum*, *S. torreyanum*, and/or *S. cuspidatum*), and usually the presence of species indicative of weakly minerotrophic conditions. These indicator species include some combination of *Myrica gale* (sweet gale), *Vaccinium macrocarpon* (large cranberry), *Carex canescens* (silvery sedge), *Lysimachia terrestris* (swamp candles), *Dulichium arundinaceum* (three-way sedge), and/or *Triadenum virginicum* (marsh St. John=s-wort).

These communities differ from other intermediate fens that also contain *Myrica gale* and/or *Carex lasiocarpa* (e.g., Types 10, 11, and 13) by the abundance of aquatic Sphagna; the higher frequency of Abog≦ plants such as *Eriophorum virginicum* (tawny cotton-grass) and *Sarracenia purpurea* (pitcher-plant); the lower frequency of certain *Carex* species; and the absence of *Sphagnum lescurii.* The *Sphagum pulchrum – Carex* moss lawn natural community sometimes has more acidic indicators than do the other natural communities in this group. Some examples may be intermediate among the three oligotrophic-weakly minerotrophic communities.

***Sphagnum pulchrum/Carex* moss lawn (1)**

This natural community corresponds to open moss lawns or pools dominated by *Sphagnum pulchrum*. The community occurs as small pools with loose *Sphagnum* carpets, or occasionally as extensive lawns associated with large lake border peatlands (e.g., peatlands around Lake Umbagog). Vascular plants are sparse but may include *Vaccinium oxycoccos* (small cranberry), *Carex limosa* (quagmire sedge), *Carex oligosperma* (few seeded sedge), *Carex utriculata* (bottle-shaped sedge), *Carex canescens* (silvery sedge), *Scheuchzeria palustris* (pod-grass), *Smilacina trifolia* (three-leaved false Solomon's seal), *Sarracenia purpurea* (pitcher-plant), and *Andromeda glaucophylla* (bog rosemary). These moss lawns or pools range from oligotrophic to weakly minerotrophic in nutrient status (average pH is 4.0); more minerotrophic examples along lake borders contain species such as *Myrica gale* (sweet gale), *Sphagnum affine*, and *S. papillosum. Sphagnum torreyanum* and *S. angustifolium* are present in some examples. Trees and tall shrubs are always absent.

This community is broadly distributed in the state. Heath shrubs are typically dwarfed (average height 0.30 m), hummocks are poorly developed, and peat is poorly decomposed.

***Sphagnum cuspidatum/Vaccinium macrocarpon* moss lawn (15)**

This community forms small to extensive floating peat mats in lake margin peatlands and in wet lagg areas along upland borders. *Sphagnum cuspidatum* is dominant and *S. torreyanum* is generally absent. *Chamaedaphne calyculata* (leather-leaf) is frequent and sometimes abundant. *Vaccinium macrocarpon* (large cranberry), *Carex canescens* (silvery sedge), and *Myrica gale* (sweet gale) are common in low to moderate abundance, and *Rhynchospora alba* (white beak-rush), *Sarracenia purpurea* (pitcher-plant), and *Eriophorum virginicum* (tawny cotton-grass) are occasional. *Sphagnum angustifolium*, *S. fimbriatum*, and *S. fallax* are infrequent. Robust *Carex* species (*Carex lasiocarpa* var. *americana* (hairy-fruited sedge), *C. utriculata* (bottle-shaped sedge), and *C. oligosperma* (few seeded sedge)) are infrequent.

This natural community is widespread in New Hampshire. The average pH is 4.2, and hummocks are moderately small (average hummock height 0.11 m; average maximum hummock height 0.20 m). Peat is moderately well decomposed in the upper 0.5 m. Dwarf shrub height averages 0.29 m.

A rare variant is dominated by the coastal plain sedge *Carex bullata* (inflated sedge)* and *Sphagnum cuspidatum*. Although known from only one peatland site in the state, this variant is probably more widespread farther south on the coastal plain and likely deserves community-level status.

Sphagnum torreyanum/Vaccinium macrocarpon/Rhyncospora alba moss lawn (14)

Like the *Sphagnum cuspidatum – Vaccinium macrocarpon* moss lawns described above, this community also forms small to extensive floating peat mats in lake margin peatlands and in wet lagg areas along upland borders. *Sphagnum torreyanum* is abundant to dominant, *S. papillosum* is occasional, and *S. affine, S. pulchrum,* and *S. cuspidatum* are infrequent. *Dulichium arundinaceum* (three-way sedge), *Vaccinium macrocarpon* (large cranberry), *Carex canescens* (silvery sedge), and *Myrica gale* (sweet gale) are common in low to moderate abundance and are indicative of weakly minerotrophic conditions. *Rhynchospora alba* (white beak-rush) is frequent, and *Juncus pelocarpus* (mud rush), *Drosera intermedia* (spatulate-leaved sundew), *Sarracenia purpurea* (pitcher-plant), and *Eriophorum virginicum* (tawny cotton-grass) are occasional. *Scheuchzeria palustris* (pod-grass), *Carex lasiocarpa* var. *americana* (hairy-fruited sedge), *C. utriculata* (bottle-shaped sedge), *C. oligosperma* (few seeded sedge), and *C. limosa* (quagmire sedge) are infrequent.

This community occurs mostly in central and southern New Hampshire but is occasional in the northern part of the state as well. Average pH is 4.3. Hummocks are moderately small (average 0.14 m (0.08)) and range to an average maximum height of 0.29 m. Peat is moderately well decomposed within the upper 0.5 m. Dwarf shrub height averages 0.42 m.

MINEROTROPHIC TYPES (CIRCUMNEUTRAL – CALCAREOUS)

Circumneutral-calcareous flark (16)

In New Hampshire, patterned fens are known to occur at only two sites and are otherwise restricted in New England to the more boreal climate of northern Maine. Of the two occurrences in New Hampshire, one site supports an acidic fen and the other has circumneutral-calcareous conditions. Slow groundwater movement through the gently sloping wetland causes the patterned or "ribbed" fen topography.

Circumneutral-calcareous flarks and flark borders at the single, northern New Hampshire site are characterized by saturated to flooded hollows lying approximately parallel to low peat ridges (strings or ribs) in the patterned fen. Vegetation is characterized by an abundant brown algal mat, low vascular plant cover (ca. 12%), and sparse cover of *Sphagnum contortum* (ca. 5%). Herbaceous plants include *Carex exilis* (meagre sedge)*, *Menyanthes trifoliata* (buckbean), *Scirpus hudsonianus* (northern cotton club rush), *Utricularia minor* (small bladderwort), *Sarracenia purpurea* (pitcher-plant), *Rhynchospora alba* (white beak-rush), *Drosera intermedia* (spatulate-leaved sundew), *Eriophorum viridi-carinatum* (green keeled cotton-grass), *Andromeda glaucophylla* (bog rosemary), *Solidago c.f. purshii* (Pursh's goldenrod)*, *Carex livida* (glaucous sedge)*, *Juncus stygius* (styx rush)*, *Carex tenuiflora* (thin-flowered sedge)*, and *Muhlenbergia glomerata* (clustered marsh muhly).

The flarks range from a few meters to more than 25 m wide with pHs ranging from 6.3 – 8.4 (-9.0). The sparse shrub cover (<1%) averages less than 20 cm in height. Peat is more than 4.8 m deep and is poorly decomposed in the upper meter.

DWARF- AND MEDIUM-SHRUB BOGS AND POOR FENS

The following communities are oligotrophic to minerotrophic and are dominated by moderately dense to dense dwarf or occasionally medium-height shrubs. If present, tall shrubs have very low cover. Average percent cover for dwarf and medium shrubs for all communities ranges from ca. 30% to 45%, in contrast to open moss lawn or mud-bottom communities, in which shrub cover averages less than 15%. Average shrub heights range from 0.16 m to 0.52 m. Trees may be present, but generally are in low abundance compared to communities that have greater cover by tall shrubs. Hummocks are better developed in these communities than in mud-bottom and moss lawn communities, and average hummock heights are greater than 0.15 m. Peat is poorly to moderately well decomposed in the upper meter, and average pH ranges from 3.8 to 4.1. These communities are divided into two distinct groups based on their occurrence in alpine/subalpine (above ca. 2900 ft.) or mid-low elevation settings (below ca. 2900 ft.). Most mid-low elevation communities are oligotrophic. One minerotrophic community type is described from a single site.

Distribution maps are presented in Appendix 5. Photographs are displayed in Appendix 6.

OLIGOTROPHIC ALPINE/SUBALPINE BOGS AND SUBALPINE HEATH SNOWBANKS (VERY ACIDIC) (4)

Most sloping and level alpine/subalpine peatlands occur in concavities on ridgelines. Others occur on moderate to steep slopes over bedrock, where some combination of limited drainage, "fog-belt" subalpine climate, late melting snowpack, and/or self-maintaining *Sphagnum* mats contributes to peat accumulation. These peatlands are dominated primarily by lowland bog plants, which are generally accompanied by subalpine plants such as *Vaccinium uliginosum* var. *alpinum* (bilberry)* and *Empetrum nigrum* (black crowberry)*. This broad classification would be improved by collecting and analyzing more bryophyte data from these peatland communities. Alpine/subalpine peatlands are restricted to the White Mountains at elevations ranging from 2900 to 4900 ft. Descriptions are adapted from those presented in Sperduto and Cogbill (1999) and modified as a result of new data from several sites.

Wet alpine/subalpine level and sloping bog
Vaccinium uliginosum-V. oxycoccos-Ledum groenlandicum/Rubus chamaemorus
alpine/subalpine bog

This community occurs on mostly level to slightly sloping peatlands, generally above 3500 ft. and dominated by *Sphagnum* mosses. It is differentiated from lowland peatlands by subalpine plants such as *Empetrum nigrum* (black crowberry)*, *Vaccinium uliginosum* var. *alpinum* (bilberry)*, and *Rubus chamaemorus* (baked apple berry)*. *Sphagnum fuscum* and *S. capillifolium* are the most common peat moss species. Others may include *Sphagnum rubellum*, *S. russowii*, and *S. lescurii*. This community is more permanently saturated than the subalpine wooded heath snowbank, slope bog, and bog margin communities described below, as indicated by the presence of *Vaccinium oxycoccos* (small cranberry), *Eriophorum vaginatum* (cotton grass), and other species indicative of saturated conditions, and usually by the absence of *Cetraria islandica* and other lichens. *Sphagnum* is a constant. *Ledum groenlandicum* (Labrador-tea) is nearly constant and other heath shrubs are frequent, including *Chamaedaphne calyculata* (leather-leaf), *Kalmia angustifolia* (sheep laurel), and *Kalmia polifolia* (bog laurel). Two variants are recognized:

1. ***Rubus chamaemorus-Scirpus cespitosus-Vaccinium uliginosum* variant**: This variant differs from the next by a higher frequency of *Vaccinium uliginosum* var. *alpinum* (bilberry)*, *Rubus chamaemorus* (baked apple berry)*, and *Scirpus cespitosus* (tussock bulrush). *Vaccinium vitis-idaea* (mountain cranberry) is occasional. *Rhododendron canadense* (rhodora) is absent. This variant can occur at higher elevations (up to ca. 4900 ft.) than the one described below.
2. ***Rhododendron canadense*/shrub heath variant**: This variant tends to lack *Scirpus cespitosus* (tussock bulrush) and *Rubus chamaemorus* (baked apple berry)*, has less *Vaccinium uliginosum* var. *alpinum* (bilberry)*, and often has a denser cover of dwarf shrubs. *Empetrum nigrum* (black crowberry)* is occasional, while *Rhododendron canadense* (rhodora) is frequent. *Picea mariana* (black spruce) is more frequent and abundant compared to the preceding variant. The *Rhododendron canadense*/shrub heath variant occurs at a maximum elevation of ca. 3700 ft. and is transitional to the subalpine wooded heath snowbank, slope bog, and bog margin community.

Subalpine wooded heath snowbank, slope bog, and bog margin

Picea mariana – Abies balsamea/Sphagnum/Cetraria islandica heath snowbank/bog border

This community is found in subalpine settings where deeper snows accumulate (e.g., on lee slopes of peaks or near krummholz margins), on drier borders of bogs, and on other moist slopes where *Sphagnum* maintains growth and peat accumulates. This community is intermediate between wet bogs and heath/krummholz communities. It differs from wetter alpine bogs by a generally higher cover of *Picea mariana* and *Abies balsamea* krummholz (stunted trees <2 m in height), abundant lichens (including *Cetraria islandica* and *Cladina rangiferina)*, and an absence of plants indicative of permanently saturated conditions, such as *Vaccinium oxycoccos* (small cranberry) and *Eriophorum vaginatum* var. *spissum* (hare's-tail). *Ledum groenlandicum* (Labrador-tea) and *Kalmia angustifolia* (sheep laurel) are common. The community differs from sheep laurel-Labrador tea heath/krummholz communities (Sperduto and Cogbill 1999) by a shallow to moderately deep peat layer (0.25-0.80+ m), an abundance of *Picea mariana* (black spruce), and the presence of bog-indicators such as *Sphagnum* moss, *Chamaedaphne calyculata* (leather-leaf), and/or *Rubus chamaemorus* (baked apple berry)*.

Subalpine sliding fen

Calamagrostis pickeringii-Scirpus cespitosus/Sphagnum compactum sliding fen

This shallow peat bog community occurs on 5-30^{o} slopes along the brow of alpine/subalpine cliffs at one site in the White Mountains. It is floristically similar to other alpine/subalpine bogs but differs by the abundance of *Calamagrostis pickeringii* (Pickering's reed bent-grass)*, *Sphagnum compactum*, and *Geum peckii* (mountain avens)*. *Scirpus cespitosus* (tussock bulrush), *Sphagnum russowii, S. capillifolium*, and *S. girgensohnii* are abundant, along with various heath shrubs. Elsewhere in the region, sliding fens can presumably become super-saturated from a major rain event and slide off the cliff (hence the name) before peat build-up resumes (pers. comm., David Hunt 1999). This is a very rare community in the state with a single documented example on top of Cannon Cliff. A few other high-elevation cliffs in the White Mountains may also contain examples of this community.

OLIGOTROPHIC – WEAKLY MINEROTROPHIC MID-LOW ELEVATION BOGS AND POOR SHRUB FENS (VERY ACIDIC – ACIDIC)

***Chamaedaphne calyculata-Kalmia angustifolia/Sphagnum capillifolium* dwarf heath shrub bog (5)**

This community is characterized by oligotrophic to weakly minerotrophic bogs and poor fens dominated by a low diversity but dense cover of dwarf- to medium-height heath shrubs, and an absence or very low abundance of tall shrubs and trees. *Chamaedaphne calyculata* (leather-leaf) is the dominant shrub, with lesser quantities of *Kalmia angustifolia* (sheep laurel) and sometimes *Rhododendron canadense* (rhodora). *Sphagnum capillifolium* is diagnostic and typically occupies hummocks. Other abundant Sphagna include *Sphagnum magellanicum* and *S. rubellum*, while *S. angustifolium* is occasional. *Polytrichum strictum* is common on hummocks, and *Carex trisperma* var. *billingsii* (Billing's sedge) is occasional. This community has a higher constancy of *S. capillifolium* and apparent lower frequency of *Picea mariana* (black spruce) than the *Chamaedaphne calyculata-Kalmia angustifolia*/*Picea mariana* dwarf heath shrub bog/very poor fen community (Type 7) described below. Scattered individuals of black spruce may occur, however, across the larger matrix of vegetation at some sites.

Hummock and hollow topography is well developed with average and average-maximum hummock heights of 0.24 m and 0.40 m, respectively. Average pH is 3.8. Shrubs average 0.52 m in height and form a relatively dense cover (35-50%) compared to other peatland communities. This community is documented from central and southern New Hampshire, but it is probably widespread in the state.

Three variants can be recognized:

1. **Dwarf-medium heath shrub bog variant**: *Sphagnum flexuosum* and *S. papillosum* are absent (average pH is 3.8), but *Kalmia angustifolia* (sheep laurel), *S. magellanicum*, and *S. capillifolium* are more prominent than in the other variants. Shrub height averages 0.60 m, but occasionally ranges to nearly 1 m in a few samples.
2. **Dwarf heath shrub bog variant**: Floristically, examples in this variant do not differ much from the oligotrophic dwarf medium shrub heath community above, but they are characterized by a shorter dwarf heath layer (shrub heights range from 0.30-0.35 m) and very oligotrophic to possibly ombrogenous conditions. This variant has very low vascular species richness compared to most other peatland communities and occupies hydrologically isolated portions of oligotrophic basin peatlands. Average pH is 3.5 (range 3.3-3.7). These are the lowest pHs recorded among lowland peatlands in the state (below 1000 ft.), and they are comparable to or more acidic than those of many alpine bogs.
3. **Weakly minerotrophic heath shrub poor fen variant**: *Sphagnum flexuosum* and *S. papillosum* are indicative of weakly minerotrophic conditions in this variant compared to the others, although pHs are quite low (average pH is 3.9). *Sphagnum magellanicum*, *S. capillifolium*, and *Kalmia angustifolia* (sheep laurel) are absent or sparse. The presence of minerotrophic Sphagna align this variant with the *Andromeda glaucophylla-Myrica*

gale-Carex utriculata/Sphagnum fallax fen community (Type 6) described in the next section; alternatively, this variant could therefore be grouped with Type 6. Shrub height averages ca. 0.60 m.

***Chamaedaphne calyculata-Kalmia angustifolia/Picea mariana* dwarf heath shrub bog/very poor fen (7)**

This community corresponds to oligotrophic dwarf heath bogs or very poor fens with essentially no tall shrubs and a sparse, stunted tree canopy of *Picea mariana* (black spruce) and/or *Larix laricina* (eastern larch) (generally 1-10% cover and less than 1-6 m in height). It is structurally similar to "muskegs" in the boreal forest region. Some combination of *Sphagnum angustifolium*, *S. rubellum*, and/or *S. magellanicum* dominates the moss layer. *Sphagnum capillifolium* is occasional but not as frequent as in the dwarf heath shrub bogs of Type 5. *Eriophorum vaginatum* var. *spissum* (hare's-tail), *E. virginicum* (tawny cotton-grass), *Smilacina trifolia* (three-leaved false Solomon's seal), and *Carex trisperma* var. *billingsii* (Billing's sedge) are frequent. *Chamaedaphne calyculata, Kalmia angustifolia, Vaccinium oxycoccus*, and *Kalmia polifolia* are characteristic of the dwarf heath layer.

Shrub height averages ca. 0.48 m, pH averages 3.8, and peat is poorly decomposed in the upper 0.5 m. Hummocks are moderately to very well developed. Canopy trees (above the tall shrub layer) average ca. 6 m in height.

Two reasonably distinct variants are described:

1. ***Sphagnum rubellum-S. angustifolium* dwarf heath variant**: This variant is most common in central and southern New Hampshire and is distinguished from the next variant by the lack of *Ledum groenlandicum* (Labrador-tea) and *Sphagnum fuscum*; a less developed hummock-hollow topography; a lower abundance of trees; and a generally stronger dominance of *Sphagnum rubellum* and *S. angustifolium*. Average pH is 3.7, heath shrubs are less than 0.5 m in height, and peat is poorly decomposed in the upper 0.75 m. Hummocks average about 0.16 m, with a maximum height of less than 0.30 m.
2. ***Ledum groenlandicum-Sphagnum fuscum* dwarf heath variant**: This variant is most common in northern New Hampshire and is distinguished by the presence of *Ledum groenlandicum* (Labrador-tea) and *Sphagnum fuscum*; a better developed hummock-hollow topography; and a higher abundance and structural complexity of the tree layer. *Carex pauciflora* (few-flowered sedge) is occasional. Hummock height averages 0.25 m, with maximum heights averaging 0.4 m. The average pH is 3.95.

INTERMEDIATE – MINEROTROPHIC (CIRCUMNEUTRAL) TYPE

***Thuja occidentalis* circumneutral string (27)**

In New Hampshire, patterned fens are known to occur at only two sites and are otherwise restricted in New England to the more boreal climate of northern Maine. Of the two occurrences in New Hampshire, one site supports an acidic or "poor" fen and the other has circumneutral-calcareous conditions. Slow groundwater movement through the gently sloping wetland causes the patterned or "ribbed" fen micro-topography.

Circumneutral strings or "ribs" at the single, northern New Hampshire site are characterized by saturated, low peat ridges lying approximately parallel to saturated or flooded circumneutral-calcareous flarks. The strings are dominated by stunted (and heavily browsed) *Thuja occidentalis* (northern white cedar), averaging 1 m tall (ranging from <1 m to 7 m tall). The most common medium to short shrub associates include *Chamaedaphne calyculata* (leather-leaf), *Ledum groenlandicum* (Labrador-tea), *Andromeda glaucophylla* (bog rosemary), and *Salix pedicallaris* (bog willow). Scattered *Thuja occidentalis*, *Picea mariana* (black spruce), *Larix laricina* (eastern larch), and *Acer rubrum* (red maple) reach heights of 5-7 m in the tall shrub layer. *Carex exilis* (meagre sedge)* and less frequently *Drosera rotundifolia* (round-leaved sundew), *Osmunda regalis* var. *spectabilis* (royal fern), *Sarracenia purpurea* (pitcher-plant), *Aster radula* (rough-leaved aster), *Solidago c.f. purshii* (Pursh's goldenrod)*, *Menyanthes trifoliata* (buckbean), *Muhlenbergia glomerata* (clustered marsh muhly), *Carex trisperma* var. *billingsii* (Billing's sedge), *Scirpus hudsonianus* (northern cotton club rush), and few others characterize the poorly developed herb layer. A diverse moss flora from one 10 x 10 m plot was characterized by *Sphagnum angustifolium, S. warnstorfii, S. magellanicum, S. rubellum, S. fuscum, Tomenthypnum nitens, Hylocomnium splendens, Pleurozium schreberi, Aulocomnium palustre*, and *Dicranum undulatum*.

The strings average 0.30 m in height and range from a few meters to more than 10 m wide. The pHs range from 6.3 – 6.7. Peat extends to more than 4.8 m in depth and is poorly to moderately decomposed in the upper meter.

SEDGE AND SHRUB/GRAMINOID FENS

Distribution maps are presented in Appendix 5. Photographs are displayed in Appendix 6.

WEAKLY MINEROTROPHIC TYPES (ACIDIC)

***Andromeda glaucophylla-Myrica gale/Carex utriculata/Sphagnum fallax* fen (6)**

These are weakly minerotrophic fens dominated by a mixture of dwarf shrubs, *Carex* species, and several Sphagna; trees and tall shrubs are sparse or absent. They differ from other fens that contain *Myrica gale* (sweet gale) and *Carex utriculata* (bottle-shaped sedge) in the abundance of *Sphagnum fallax*, *S. angustifolium*, and *S. magellanicum*, and some combination of *Andromeda glaucophylla* (bog rosemary), *Kalmia polifolia* (bog laurel), *Vaccinium oxycoccos* (small cranberry), and *Smilacina trifolia* (three-leaved false Solomon's seal). *Chamaedaphne calyculata* (leather-leaf) is usually a dominant, and *Carex utriculata* and/or *Carex oligosperma* (few seeded sedge) are frequently present. *Carex paupercula (bog sedge), Carex lacustris* (lake sedge), *Symplocarpus foetidus* (skunk cabbage), and *Betula pumila* (swamp birch)* are infrequent in the community overall but abundant in one example. Swamp birch is known from only one site in the state, in relatively acidic conditions.

Shrub stature is dwarfed with an average height of 0.49 m. Average pH is 4.12. Hummocks are weakly developed (average height 0.16 m and usually <0.20 m) and peat is poorly decomposed in the upper 0.5 m. This community occurs primarily in central and southern New Hampshire.

***Myrica gale-Spiraea alba/Carex stricta* streamside/pond-border fen (10b)**

This community is typically limnogenous and occurs along stream or pond borders and other moderately minerotrophic settings at low-mid elevations throughout the state. *Myrica gale* (sweet gale), *Spiraea alba* (meadow-sweet), and *Carex stricta* (tussock sedge) are diagnostic and usually present in some combination, and tall shrubs are sparse (<5%) or absent. *Myrica gale* and *Chamaedaphne calyculata* (leather-leaf) are robust (average height 0.90 m), nearly constant, and abundant. The herb layer is moderately well developed and typically contributes 5-25% cover (average is 18%). Several herbaceous species are present in low abundance, including *Calamagrostis canadensis* (blue-joint), *Carex lasiocarpa* (hairy-fruited sedge), *Carex utriculata* (bottle-shaped sedge), *Typha latifolia* (common cat-tail), *Lysimachia terrestris* (swamp candles), *Triadenum virginicum* (marsh St. John=s-wort), and *Carex canescens* (silvery sedge). *Sphagnum fimbriatum* and *S. henryense* are frequent, and *S. cuspidatum* is occasional.

Average pH is 4.5. Peat is moderately well decomposed near the surface (H5 at 0.20 m) and hummocks are well developed (average height 0.25 m; average maximum height 0.43 m).

***Decodon verticillatus/Sphagnum recurvum-S. flexuosum* border thicket (11)**

This community occurs in wet minerotrophic settings along pond borders, laggs, and other upland border situations. It is dominated by minerotrophic *Sphagnum* species including *S. recurvum*, *S. flexuosum*, *S. fimbriatum*, and occasionally *S. papillosum*. *Decodon verticillatus* (water willow) is usually but not always present, and it can occur in other communities. Other frequent species include *Carex canescens* (silvery sedge), *Chamaedaphne calyculata* (leather-leaf), *Myrica gale* (sweet gale), *Lysimachia terrestris* (swamp candles), and *Triadenum virginicum* (marsh St. John=s-wort). *Vaccinium corymbosum* (highbush blueberry) is infrequent and in low abundance. This community occurs in southern and central New Hampshire. *Sphagnum recurvum* and *Decodon verticillatus* have southern or coastal affinities.

Average pH is 4.4, and hummocks are usually moderately well developed (average height 0.25 m). Peat is relatively well decomposed near the surface. Average medium shrub height is 0.95 m. This community occurs in southern and central New Hampshire.

Montane *Calamagrostis pickeringii*/shrub level/sloping fen (25)

This community is restricted to the upper East Branch of the Pemigewasset River watershed near Shoal and Ethan Pond in the White Mountains above elevations of 2400 ft. It forms in level to sloping positions along slow drainages or seepy slopes lacking drainage channels. Climate, hydrologic conditions, and soil features are probably the primary factors contributing to the development of this unique wetland community. Structurally, this community is graminoid-shrub dominated. This type co-occurs with montane shrub communities (see Type 24) with a high cover of medium to tall shrubs, scattered sapling-sized trees, and small graminoid/moss lawn openings.

The vegetation is typically dominated by *Calamagrostis pickeringii* (Pickering's reed bent-grass)*, *Carex oligosperma* (few seeded sedge), and *Carex echinata* (prickly sedge). *Sphagnum* mosses are abundant. Although complete bryophyte surveys have not been conducted, documented species include *Sphagnum subtile, S. angustifolium,* and *Sphagnum girgensohnii.*

Other occasional species include *Vaccinium oxycoccos* (small cranberry), *Eriophorum virginicum* (tawny cotton-grass), *Sarracenia purpurea* (pitcher-plant), *Drosera rotundifolia* (round-leaved sundew), *Aster radula* (rough-leaved aster), *Carex trisperma* var. *trisperma* (three-seeded sedge), *Carex pauciflora* (few-flowered sedge), *Carex wiegandii* (Wiegand's sedge)*, *Coptis trifolia* var. *groenlandica* (goldthread), *Dalibarda repens* (false violet), *Juncus brevicaudatus* (short-tailed rush), *Platanthera clavellata* (small green woodland orchid), and *Solidago purshii* (Pursh's goldenrod)*. Woody plants are sparse to frequent and may form a mosaic with moderate to large graminoid dominated areas. Shrubs and trees may include *Rhododendron canadense* (rhodora), *Nemopanthus mucronatus* (mountain holly), *Viburnum nudum* var. *cassinoides* (witherod), *Larix laricina* (eastern larch), *Picea mariana* (black spruce), *Picea rubens* (red spruce), *Ledum groenlandicum* (Labrador-tea), *Vaccinium myrtilloides* (velvet-leaf blueberry), and less frequently *Alnus incana* var. *americana* (speckled alder), *Kalmia angustifolia* (sheep laurel), and *Amelanchier bartramiana* (Bartram's serviceberry).

Soils are characterized by shallow organics over hydric, cryic, silty gravels. Organic soil depths are generally deeper than those underlying the related montane alder-heath shrub thicket. At two sites, pH readings were 4.6 and 4.7. Hummock and hollow topography is moderately to poorly developed.

INTERMEDIATE TYPES (SUBNEUTRAL)

***Carex lasiocarpa/Myrica gale-Vaccinium macrocarpon* sedge fen (13)**

This is a widespread, intermediate (minerotrophic) fen community often associated with lake and pond margins. It is also occasional along upland borders of some kettle holes or along floating mats of lake-fill peatlands. *Carex lasiocarpa* var.*americana* (hairy-fruited sedge) and *Myrica gale* (sweet gale) are usually present. *Carex utriculata* (bottle-shaped sedge) is frequent, and *Carex oligosperma* (few seeded sedge) is occasional. At least one of these three sedge species is always present. Forbs indicative of intermediate nutrient status are usually present in low abundance, including *Lysimachia terrestris* (swamp candles), *Triadenum virginicum* (marsh St. John=s-wort), and *Sagittaria latifolia* (common arrowhead). *Vaccinium macrocarpon* (large cranberry) can be common but is not always present. *Spiraea alba* var.*latifolia* (eastern meadow-sweet), *Calamagrostis canadensis* (blue-joint), and *Typha latifolia* (common cat-tail) are occasional, particularly when *Vaccinium macrocarpon* is absent. *Peltandra virginica* (arrow-arum) is occasional. *Sphagnum* may be absent but usually forms a sparse to moderate cover that may include *Sphagnum lescurii* (frequent) and *S. torreyanum* (occasional). *Sphagnum cuspidatum, S. fimbriatum*, and *S. affine* are uncommon. *Chamaedaphne calyculata* (leather-leaf) is occasional, but medium and tall shrubs and trees are sparse or absent.

Average pH is 4.9. Hummocks are low to moderately sized (average height 0.19 m), and peat is moderately to well decomposed within the upper 0.5 m. Many examples along lakes consist of moderately shallow peat layers underlain by lake silts.

Calcareous sedge/moss fen (26)

Carex flava-Carex interior/Campylium stellatum calcareous fen

Calcareous sedge/moss fens occur in northern New Hampshire in a variety of "disturbed" or groundwater influenced hydrological settings where groundwater seepage has a year-round influence and contributes a relatively high proportion of the water budget. These settings include (1) headwater positions, (2) marginal areas of lakes and stream drainages through marshes or swamps, (3) beaver meadows, (4) gaps in calcareous seepage swamps (e.g., cedar swamps), (5) other small basins, kettles, or catchments with seepage influence, (6) steep terraces of major rivers or minor stream drainages where seepage emerges and more moderately sloping side slopes of hills, and (7) grazed pastures. All of these settings have some or a considerable level of seepage influence and a tendency to stay open to one degree or another, depending on other factors. In addition, disturbance intensity varies and may be either natural or artificial in character.

Characteristic vegetation includes *Carex interior* (inland sedge), *Carex flava* (yellow sedge), *Carex hystricina* (porcupine sedge), *Drosera rotundifolia* (round-leaved sundew), *Eleocharis tenuis* (slender spike rush), *Equisetum fluviatile* (water horsetail), *Eriophorum virginicum* (tawny cottongrass), *Geum rivale* (water avens), *Platanthera hyperborea* (northern green orchis), *Platanthera psycodes* (purple-fringed orchid), *Platanthera dilatata* (white bog orchis), *Scirpus hudsonianus* (cotton bulrush), *Scirpus rubrotinctus (=microcarpus)* (red-tinged bulrush), *Senecio robbinsii* (Robbins ragwort), *Thuja occidentalis* (northern white cedar), and *Typha latifolia* (common cat-tail). Other species frequent in calcareous fens that may also occur in other habitats include *Equisetum arvense* (field-horsetail), *Eupatorium maculatum* (spotted Joe-pye-weed), *Fragaria virginiana* (wood strawberry), *Glyceria striata* (manna-grass), *Hydrocotyle americanum* (water pennywort), *Juncus tenuis* (=dudleyi) (path rush), *Juncus nodosus* (noded rush), *Salix lucida* (shinning willow), *Salix discolor* (large pussy willow), *Salix bebbiana* (long-beaked willow), and *Thelypteris palustris* (marsh fern).

Rare plants occurring in calcareous fens include *Spiranthes rommanzofiana* (hooded ladys' tresses)*, *Equisetum variegatum* (variegated horsetail)*, *Cypripedium reginae* (showy lady's slipper)*, *Lobelia kalmii* (Kalm's lobelia)*, *Petasites frigidus* var. *palmatus* (sweet coltsfoot)*, *Carex bebbii* (Bebb's sedge)*, *Carex castanea* (chestnut sedge)*, *Equisetum palustre* (marsh horsetail)*, *Equisetum pratense* (meadow horsetail), *Carex aurea* (golden-fruited sedge)*, and *Eleocharis pauciflora* var. *fernaldii* (few-flowered spikerush)*.

Bryophytes often found in calcareous fens include *Aulacomnium palustre*, *Sphagnum warnstorfii*, *Tomenthypnum nitens*, *Mnium affine* var. *rugicum*, *Mnium cuspidatum*, *Bryum pseudo-triquetrum*, *Campylium stellatum*, *Climaceum dendroides*, *Fissidens adianthoides*, *Helodium blandowii*, *Hypnum pratense*, *Lophoclea* sp., *Philinotus fontana*, and *Pellia epiphylla*.

Soils typically have shallow to moderate organic horizon depths (0.2-1.2+ m) of poorly to well decomposed peat (depending on depth). Muck or peaty muck layers are found at some sites, particularly in active pasture fens where there has presumably been more mixing of shallow peat with underlying mineral horizons due to bovine traffic. Underlying till, or less often outwash soils, invariably have a significant gravelly or stony silt or silty muck soil that impedes downward movement of water.

Calcareous fens appear to have a strong correlation with bedrock and till source material containing a significant amount of calcium and other base-cations. Bedrock types in New Hampshire with these qualities include the Waits River, Fitch, and Ammonoosuc Volcanic Formations, and to a lesser extent syenites, diorites, Gile Mountain Formation, and others.

Average pH is 7.2 and ranges from 6.7 to 8.2, with one aberrant pH of 6.2. Conductivity ranges from 90 to 380 microsiemens, with two aberrant readings of 60 and 750.

Floristic and environmental differences may vary significantly from site to site. Given this variability, and because there are only a few examples of each community known from New Hampshire, they are better viewed as variants rather than community types until their differences in composition, distribution, and landscape context are better understood. Any of the following variants may differ depending on the frequency, intensity, and timing of grazing by livestock. The more active the pasturing, the greater the prominence of non-native pasture grasses and forbs, and of native ruderals. Intense pasturing appears to mix peat and mineral horizons into shallow peaty-mucks.

1. **Sloping typic variant**: This variant occurs on shallow peat (less than 0.5 m) and occurs in slightly sloping headwater positions of drainages and former pastures.
2. **Level/shallow sloping deep peat variant**: This variant has deeper peats (0.5-1+ m) and is often found in more level positions or natural basins and drainage margins where basin morphology and hydrology has led to significant peat accumulations: often occurs as temporary to semi-permanent natural openings in *Thuja occidentalis* (northern white cedar) swamps.
3. **Steep slope *Equisetum* variant**: This variant occurs on seepy, steep river terraces or headwater drainage positions with shallow peat and a strong prominence of *Equisetum* species (horsetails).
4. ***Beaver meadow variant***: This variant occurs in marsh drainages behind old beaver impoundments in calcareous regions. Few examples are known, but clearly these wetlands have a different long- and short-term disturbance regime. Orchids appear to be sparse, and certain graminoids may be more prominent in these situations than in the above variants (e.g., *Carex utriculata* (beaked sedge), *Carex bebbii* (Bebb's sedge)*, *Calamagrostis canadensis* (blue-joint), and the rare *Eleocharis pauciflora* var. *fernaldii* (few-flowered spikerush)*), but calciphiles are present, distinguishing this variant from typical beaver meadows. Presumably, a beaver meadow variant is also a temporary phase in a natural successional cycle either toward woody plants (with drainage or sedimentation of the meadow) or toward aquatic vegetation (when flooded).

Graminoid-forb-sensitive fern seepage marsh (12b)

Seepage marshes occur in association with groundwater discharge zones near upland borders of various wetland types, in headwater positions, along stream drainages (including the interface of a drainage with a larger marsh), or in other areas where groundwater discharge is prominent. They tend to be larger than forest seeps and do not have a significant tree canopy influence, except along the borders. Seepage marshes are intermediate between fens and marshes both

floristically and environmentally. All contain a mixture of graminoids, forbs, and ferns including indicators of seepage and minerotrophic conditions. All known examples have shallow peat or muck organic layers over silt or silty muck. Mosses may be abundant but *Sphagnum* is generally absent. At this time, specific communities or variants are not described, although floristic variation and distributional patterns suggest that several communities could be described with the collection of additional data. Examples dominated by *Carex lacustris* (lake sedge) are the most frequently observed and will likely be described as a distinct community in the future.

Potential dominant species indicative of seepage or minerotrophic conditions include *Onoclea sensibilis* (sensitive fern) (high frequency among known examples), *Carex lacustris* (lake sedge), *Eupatorium maculatum* (spotted Joe-pye-weed), *Osmunda regalis* (royal fern), *Thelypteris palustris* (marsh fern), *Symplocarpus foetidus* (skunk cabbage), *Saxifraga pensylvanica* (swamp saxifrage), and *Carex scabrata* (scabrous sedge). Other minerotrophic indicators usually present in lower abundance may include *Senecio robbinsii* (Robbins ragwort), *Hydrocotyle americana* (common water pennywort), *Chrysosplenium americanum* (golden saxifrage), *Carex stipata* (awl sedge), *Carex leptalea* (delicate sedge), *Carex prasina* (drooping sedge), *Impatiens capensis* (spotted touch-me-not), *Mentha arvensis* (field mint), *Toxicodendron vernix* (poison sumac), *Chelone glabra* (white turtlehead), *Lysimachia terrestris* (swamp candles), and *Equisetum fluviatile* (water horsetail). Other occasionally abundant species indicative of at least weakly minerotrophic conditions may include *Calamagrostis canadensis* (blue-joint), *Equisetum arvense* (field horsetail), *Aster puniceus* (purple stemmed aster), *Potentilla palustris* (marsh cinquefoil), *Spiraea alba* (meadow-sweet), and *Carex lasiocarpa* var. *americana* (hairy-fruited sedge). Mosses include *Mnium* spp. and *Philinotis fontana*, among many others. Other common marsh plants may be present as well, including *Carex lurida* (sallow sedge). Soils tend to be shallow fibric peats or mucks over silts or silty sands. In four examples, pHs range from 5.5 to 6.3, indicating subneutral-circumneutral conditions.

TALL – MEDIUM SHRUB THICKET/SPARSE WOODLANDS

Tall – medium shrub thicket peatlands usually occur as part of a mosaic with other peatland communities, but they can be the primary community in some peatland basins. Compared to peatlands dominated by shorter vascular plants, the presence of tall shrubs is usually associated with some combination of greater minerotrophic status, drier hydroperiod, or a seasonally variable water table resulting from topographic runoff. Hummocks are usually well developed. The medium-height shrub layer is usually well developed (greater than 0.5 m tall), and in some examples, it may be more abundant than the tall shrub layer.

Distribution maps are presented in Appendix 5. Photographs are displayed in Appendix 6.

OLIGOTROPHIC – WEAKLY MINEROTROPHIC TYPES (VERY ACIDIC – ACIDIC)

***Vaccinium corymbosum-Nemopanthus* shrub thicket/sparse woodland (8)**

This is an oligotrophic to weakly minerotrophic community characterized by a mixture of tall and medium height heath shrubs, and usually a sparse canopy of *Picea mariana* (black spruce),

Larix laricina (eastern larch), and sometimes *Pinus strobus* (white pine) or *Pinus rigida* (pitch pine). This community occurs over large areas of perched basins or more commonly as a border thicket around more open dwarf heath peatlands, including kettle hole bogs. A mixture of northern and more southern or coastal species is characteristic. Tall shrubs average ca. 15% cover (range is 1-30%) and usually include *Vaccinium corymbosum* (highbush blueberry), *Nemopanthus mucronatus* (mountain holly), *Lyonia ligustrina* (male-berry), and *Aronia melanocarpa* (black chokeberry). *Ilex verticillata* (winterberry) and forbs indicative of more minerotrophic conditions are generally not present. Dwarf and medium-height shrubs are on average more abundant (34% cover) than tall shrubs and include *Chamaedaphne calyculata* (leather-leaf), *Kalmia angustifolia* (sheep laurel), *Gaylussacia baccata* (black huckleberry), and occasionally *K. polifolia* (bog laurel). *Woodwardia virginica* (Virginia chain-fern) and *Carex trisperma* var. *billingsii* (Billing's sedge) are occasional. *Sphagnum magellanicum* is dominant, while *S. rubellum* is characteristic but less frequent and abundant than in *Sphagnum rubellum/Vaccinium oxycoccus* dwarf heath moss lawns that lack tall shrubs. *Sphagnum barlettianum*, a species with coastal and southern distributional tendencies, is infrequent.

This community generally occurs in southern and central New Hampshire, and rarely farther north at low elevations (below 1300 ft.). Average pH is 3.9. The medium shrub layer averages ca. 0.85 m in height and is therefore taller than that of dwarf heath communities. Peat is moderately well decomposed within the upper 0.5 m, and hummock-hollow topography is moderately well developed (average hummock height 0.26 m).

Two variants are apparent:

1. ***Rhododendron canadense-Nemopanthus mucronatus-Sphagnum russowii* variant**: This variant is characterized by a much higher frequency and abundance of *Rhododendron canadense* (rhodora) and *Sphagnum russowii* with little or no *Vaccinium corymbosum* (highbush blueberry). The most frequent tall shrub species are *Nemopanthus mucronatus* (mountain holly) and *Viburnum nudum* var. *cassinoides* (witherod). Peat is moderately well decomposed within 0.25 m of the surface. Other hummock *Sphagnum* mosses include *S. capillifolium* and *S. fuscum*. *Sphagnum russowii* is occasional but more frequent than in the next variant, and *S. angustifolium* is occasional to sometimes abundant.
2. ***Vaccinium corymbosum-Gaylussacia baccata-Vaccinium macrocarpon* variant**: This variant has a higher frequency and abundance of *Vaccinium corymbosum* (highbush blueberry) and *Gaylussacia baccata* (black huckleberry), and *Vaccinium macrocarpon* (large cranberry) occurs in low abundance. *Rhododendron canadense* (rhodora) and *Nemopanthus mucronatus* (mountain holly) are occasional but not as frequent as in the other variant. There is also a higher frequency of dwarfed *Picea mariana* (<1.5 m). Peat is poorly decomposed to a greater depth (0.7 m). Otherwise the two variants are quite similar environmentally and structurally.

WEAKLY MINEROTROPHIC MONTANE TALL SHRUB THICKET/SPARSE WOODLANDS (24)

In New Hampshire, montane tall shrub thickets described here have a sparse woodland to woodland structure and are restricted to flat ridges and slopes near the transition to heath/krummholz and in the upper East Branch of the Pemigewasset River watershed in the White Mountains. Climate, hydrologic conditions, and soil features are probably the primary factors contributing to the development of these unique wetlands. Two natural communities are distinguished primarily by the relative abundance of *Alnus incana* var. *americana* (speckled alder) and the degree of tree canopy cover. They differ from more lowland tall-medium shrub thickets by the absence of more southern or coastal species such as *Vaccinium corymbosum* (highbush blueberry), *Gaylussacia baccata* (black huckleberry), and *Woodwardia virginica* (Virginia chain-fern).

Montane heath shrub thicket/sparse woodland

Montane heath shrub thicket/sparse woodlands are found on mesic to wet-mesic sites on flat ridges and slopes near the transition to heath/krummholz. This community occurs in several locations in the White Mountains at the transition to subalpine communities and in association with *Calamagrostis pickeringii*/shrub level/sloping fens in the upper Pemigewasset River valley. It occurs at elevations ranging from 2500 to 4000 ft. This peatland community is similar to subalpine heath snowbanks but is distinguished from them by a lack of subalpine species, a taller woodland structure (>2 m), and a robust (0.4-1.5 m tall) shrub layer. Trees in the sparse woodland canopy include *Picea mariana* (black spruce) and/or *Picea rubens* (red spruce) and *Abies balsamea* (balsam fir). A well developed, medium to tall heath shrub layer is characterized by *Rhododendron canadense* (rhodora), *Nemopanthus mucronatus* (mountain holly), *Ledum groenlandicum* (Labrador-tea), *Kalmia angustifolia* (sheep laurel), and *Viburnum nudum* var. *cassinoides* (witherod). *Alnus incana* var. *americana* (speckled alder) is absent or in low abundance in this natural community. Soils are shallow peat over bedrock or silty gravel.

Montane alder-heath shrub thicket

The montane alder-heath shrub thicket community is restricted to the upper East Branch of the Pemigewasset River watershed near Shoal and Ethan Pond in the White Mountains at elevations above 2400 ft. Structurally, it is dominated by tall shrubs with scattered trees and small openings supporting herbaceous plants. Characteristic shrubs include *Alnus incana* var. *americana* (speckled alder), *Rhododendron canadense* (rhodora), *Nemopanthus mucronatus* (mountain holly), and *Viburnum nudum* var. *cassinoides* (witherod). Other common plants include *Ledum groenlandicum* (Labrador-tea), *Vaccinium myrtilloides* (velvet-leaf blueberry), *Gaultheria hispidula* (creeping snowberry), *Larix laricina* (eastern larch), and *Picea mariana* (black spruce). Scattered herbaceous vascular plants found in small openings include *Eriophorum virginicum* (tawny cotton-grass), *Drosera rotundifolia* (round-leaved sundew), *Carex trisperma* (three-seeded sedge), *Calamagrostis pickeringii* (Pickering's reed bent-grass)*, *Thalictrum pubescens* (tall meadow rue), *Aster umbellatus* (umbellated aster), *Chelone glabra* (turtlehead), *Carex intumescens* (bladder sedge), and *Glyceria melicaria* (a mannagrass). *Sphagnum* mosses are abundant.

Soils are characterized by shallow organics over hydric, cryic, silty gravels. Organic soil depths are generally shallower than those underlying the related montane *Calamagrostis pickeringii*/shrub level/sloping fen. Near-surface water pH is 5.0. Hummock and hollow topography is moderately developed.

WEAKLY MINEROTROPHIC – INTERMEDIATE TYPES (ACIDIC – SUBNEUTRAL)

Type 12a corresponded to seepage swamp woodlands and is not described below because tree cover was too dense for this to be considered an open peatland type. Its counterpart, Type 12b, corresponds to open seepage marshes and is described above with sedge and shrub/graminoid fens.

***Ilex verticillata/Osmunda cinnamomea/Picea* tall shrub thicket/sparse woodland (9a)**

This is a weakly to moderately minerotrophic tall shrub thicket community that occurs in central and southern New Hampshire. It is floristically transitional between more northern oligotrophic *Vaccinium-Nemopanthus* tall shrub thickets and more central and southern *Ilex verticillata* (winterberry) thickets and woodlands that lack *Picea mariana* (black spruce) and *Larix laricina* (eastern larch). This community is characterized by *Picea mariana*, *Larix laricina*, and various tall, northern shrub species. *Acer rubrum* (red maple), *Ilex verticillata*, and *Osmunda cinnamomea* (cinnamon fern) are more typical of the southern communities. Other characteristic shrubs include *Vaccinium corymbosum* (highbush blueberry), *Nemopanthus mucronatus* (mountain holly), *Lyonia ligustrina* (male-berry), and *Viburnum nudum* var. *cassinoides* (witherod). The tree layer is sparse (ca. 1-20% cover), and the tall shrub layer is moderate to dense (average ca. 40% cover, including tree species in the shrub layer). The medium shrub layer is sparse to moderately well developed (1-25% cover, average height 0.85 m), including *Kalmia angustifolia* (sheep laurel), *Myrica gale* (sweet gale), and *Gaylussacia baccata* (black huckleberry). Low shrubs occupy hummocks and include *Gaultheria hispidula* (creeping snowberry), *Vaccinium myrtilloides* (velvet-leaf blueberry), and *Rubus hispidus* (bristly dewberry). The most prominent herbs are *Osmunda cinnamomea* (cinnamon fern), *Smilacina trifolia* (three-leaved false Solomon's seal), and *Carex trisperma* var. *trisperma* (three-seeded sedge). *Aster nemoralis* (bog aster) and *Aster* x *blakeii* (Blakes aster) are occasional. An abundant moss cover is characterized by a combination of *Sphagnum henryense, S. palustre, S. fallax,* and *S. angustifolium*, indicating minerotrophic to weakly minerotrophic conditions.

This community has an average pH of 4.35. Well decomposed peat occurs near the surface (H8 at 20 cm), and hummock and hollow topography is well developed (average hummock height 0.32 m, average maximum height 0.50 m).

***Ilex verticillata/Osmunda cinnamomea/Sphagnum fallax* tall-medium shrub thicket (9b)**

This community is weakly minerotrophic and typically occurs in laggs or as an upland border zone in southern and central New Hampshire peatlands (below 1000 ft. elevation). *Acer rubrum* (red maple) is always present in low abundance in the sparse, low-tree canopy or tall shrub layer, but tall shrubs and variable mixtures of medium shrubs and herbaceous species dominate the

community. A few examples are dominated by herbs such as *Carex canescens* (silvery sedge) and have little shrub cover.

Herbaceous species indicative of at least weakly minerotrophic conditions are in low abundance but are diagnostic. These include *Osmunda cinnamomea* (cinnamon fern), *Carex canescens* (silvery sedge), *Lysimachia terrestris* (swamp candles), *Triadenum virginicum* (marsh St. John's-wort), *Lycopus uniflorus* (common water horehound), and *Carex stricta* (tussock sedge; occasionally abundant). *Calla palustris* (wild calla), *Iris versicolor* (northern blue flag), and *Typha latifolia* (common cat-tail) are occasional in wet hollows. Tall shrubs are always present but vary from ca. 5-40% cover. Characteristic tall shrubs include *Vaccinium corymbosum* (highbush blueberry), *Ilex verticillata* (winterberry), *Lyonia ligustrina* (male-berry), *Nemopanthos mucronatus* (mountain holly), *Alnus incana* (speckled alder), and *Aronia melanocarpa* (black chokeberry). *Decodon verticillatus* (water willow) is occasionally abundant, and *Chamaedaphne calyculata* (leather-leaf), *Kalmia angustifolia* (sheep laurel), *Gaylussacia baccata* (black huckleberry) are common. *Clethra alnifolia* (sweet pepperbush) is occasional in coastal examples. *Sphagnum fallax* (*sensu latu*) is frequent and usually abundant (=*Sphagnum fallax* (*sensu stricta*) and *S. isoviitae*). *Sphagnum fimbriatum* and *S. cuspidatum* are frequent, while *S. henryense*, *S. recurvum*, and *S. affine* are occasional. The moss *Aulacomnium palustre* is occasional.

Average pH is 4.4. Peat is well decomposed near the surface (H6 at 0.2 m), and hummock-hollow topography is well developed (average hummock height is 0.22 m; average maximum height is 0.44 m). Medium shrub height averages 0.84 m.

***Vaccinium corymbosum/Myrica gale-Spiraea alba* tall-medium shrub thicket (10a)**

This is a weakly to moderately minerotrophic, limnogenous community dominated by medium height shrubs (average height 0.90 m) with a sparse to moderate cover of tall shrubs. It is found along upland borders and laggs of acidic fens, along sluggish stream borders, and sometimes as the dominant fen community in basins that are influenced by upland runoff. This community is found primarily at low to mid elevations (below1500 ft.) in central and southern New Hampshire, but it does occur occasionally in the northern part of the state. *Myrica gale* (sweet gale) and *Spiraea alba* (meadow-sweet) are diagnostic in combination with tall shrubs, including various combinations of *Vaccinium corymbosum* (highbush blueberry), *Lyonia ligustrina* (male-berry), *Aronia melanocarpa* (black chokeberry), *Ilex verticillata* (winterberry), and *Alnus incana* (speckled alder). *Chamaedaphne calyculata* (leather-leaf) is always present in low to moderate abundance. *Acer rubrum* (red maple) is common in low abundance in the tall shrub and low tree layers. *Carex utriculata* (bottle-shaped sedge), *Kalmia angustifolia* (sheep laurel), and *Rhododendron canadense* (rhodora) are occasional. Bryophyte cover is moderate (average ca. 50% cover), with *Sphagnum fimbriatum*, *S. henryense*, *S. torreyanum*, *S. flexuosum*, and *S. fallax* usually present in some combination.

Average pH is 4.6. Hummock-hollow topography is well developed (average hummock height 0.25 m; average maximum height 0.47 m), and peat is moderately well decomposed near the surface (H6 at 0.20 m). Peat depths are often less than 1 m.

MARSHY PEATLAND-MARGIN COMMUNITIES

These peatland communities occur adjacent to quiet pond and lake borders, stagnant streams, or upland habitats where a minerotrophic influence from upland runoff or open water exists. They may be transitional to aquatic beds, emergent marshes, shrub thickets, or upland habitats. Some peatland types described elsewhere may occur along pond or upland borders but do not contain an abundance of emergent or aquatic marsh species indicative of the two types below.

Distribution maps are presented in Appendix 5. Photographs are displayed in Appendix 6.

Floating marshy peat mat (23)

This community occurs along quiet margins of ponds and lakes or stagnant, slow-moving streams on floating, loosely consolidated, thin, well-decomposed peat. It is transitional between an emergent marsh/aquatic bed and an open peatland on thicker, more consolidated peat landward. Species composition is somewhat variable and may include *Nymphaea odorata* (white water-lily), *Nuphar variegata* (variegated yellow pond-lily), *Eriophorum viridicarinatum* (green keeled cotton-grass), *Eleocharis flavescens* var. *olivacea* (olive-brown spike-rush), *Eleocharis smallii* (Small's spike-rush), *Rhynchospora alba* (white beak-rush), *Drosera intermedia* (spatulate-leaved sundew), *Triadenum virginicum* (marsh St. John's-wort), *Dulichium arundinaceum* (three-way sedge), *Utricularia* spp. (bladderworts), *Pontederia cordata* (pickerel-weed), *Iris versicolor* (northern blue flag), *Juncus pelocarpus* (mud rush), *Hypericum boreale* (northern St. John's-wort), and other forbs and graminoids. Shrubs are sparse and stunted or absent.

The depth of the floating peat mat ranges from a few to more than 50 cm, and pHs range from 4.4-5.7 and are influenced by the close proximity of the peat mat to open water. The mat surface is flat with occasional, very low micro-relief and ranges from less than a meter to several meters wide. This community occurs throughout New Hampshire.

Marshy moat (18)

Moats are wetland zones generally found between other peatland communities and adjacent upland habitats, typically in southern and central New Hampshire. Moats may vary considerably, both within and between sites, in width (less than 1 m to more than 20 m) and in duration and frequency of flooding. They may be restricted to basins with significant yearly water fluctuations. Moat development likely is related to increased peat decomposition along the peatland edge as a result of decreased acidity and dry periods during seasonal water-level drawdown. Other peatland communities (e.g., Types 9b, 11, 14, and 15) also may occur in moat-locations; the type described here differs in the greater prominence of emergent marsh or aquatic species.

Vegetation is typically poorly to moderately developed, variable in composition, and with a number of minerotrophic indicator species. Temporarily to seasonally flooded moat zones support most of the shrub and emergent marsh species present. Emergent or aquatic species generally absent from other peatland types include *Sparganium americanum* (lesser bur-reed), *Glyceria* spp. (manna-grass), *Scirpus cyperinus* (woolly bulrush), *Eleocharis smallii* (Small's spike-rush), *Calamagrostis canadensis* (blue-joint), *Juncus canadensis* (Canada rush), and *Juncus effusus* var. *solutus* (soft rush). In semi-permanently flooded moat zones, several aquatic species may be present, including *Potamogeton* spp. (pondweeds), *Brasenia schreberi* (water

shield), *Utricularia vulgaris* (common bladderwort), *Nuphar variegata* (variegated yellow pond-lily), and *Nymphaea odorata* (white water-lily). Other characteristic emergent and other species also occasional in other peatland communities include *Peltandra virginica* (arrow-arum), *Dulichium arundinaceum* (three-way sedge), *Triadenum virginicum* (marsh St. John's-wort), *Carex canescens* (silvery sedge), *Carex lasiocarpa* var. *americana* (hairy-fruited sedge), *Lycopus uniflorus* (common water horehound), and *Lysimachia terrestris* (swamp candles). Shrubs may include *Cephalanthus occidentalis* (buttonbush), *Vaccinium corymbosum* (highbush blueberry), *Ilex verticillata* (winterberry), *Decodon verticillatus* (water willow), *Chamaedaphne calyculata* (leather-leaf), *Spiraea alba* var. *latifolia* (eastern meadow-sweet), *Aronia melanocarpa* (black chokeberry), and *Myrica gale* (sweet gale). *Sphagnum* species may be absent or when present, unconsolidated and often characterized by *Sphagnum cuspidatum* and other Sphagna found in "soupy" conditions. Moss species that may be found on woody stem bases and elsewhere in the moat include *Callicladium haldanianum*, *Hypnum pallescans*, and *Aulocomnium palustre*.

Soils are typically relatively shallow, well-decomposed peat. Because the moat is located where surface water runoff enters the peatland, nutrient availability and pHs are generally higher in the moat than in areas closer to the peatland center.

ECOSYSTEM CLASSIFICATION

Peatlands are broadly discussed in the literature, such as Damman and French (1987), but descriptions of peatland ecosystems based on repeating groups of community types are less common. We present a classification of New Hampshire peatland ecosystems based on the patterns of repeating associations of natural communities at 93 peatland sites in the state.

This ecosystem classification has at least three potential uses: (1) as a tool for communicating about and comparing entire sites without the awkwardness of having to refer to all communities at the site; (2) as potential units for comparing coarse-scale differences among sites for conservation purposes; and (3) to allow general classification of a peatland when detailed information is not available or detailed surveys are not feasible.

In developing the ecosystem classification, we first identified all communities at the 93 sites based on plot data and other descriptive notes from each site. We restricted the analysis to non-forested communities. These included the 24 community types described in this report in addition to several other non-peatland communities that were often associated with open peatlands within the same basin. These non-peatland communities included five broad types: (1) emergent marsh; (2) alder thickets; (3) lake or pond (with outlet); (4) kettle hole pond (no outlet); and (5) stream. It is important to emphasize that our intent with the last three non-peatland types was to reflect plants that correspond to these communities as opposed to landforms or geomorphic settings.

Second, we ran a TWINSPAN analysis of the data set where sites were the "plots" (sample units) and communities were the attributes of each site. From this analysis, we described 11 ecosystem types within four broad groups (Appendix 4). Each ecosystem type is defined by a group of sites that tend to have the same combination of community types. These particular combinations of communities are different in each ecosystem type. Appendix 4 displays the

hydrology, nutrient regime, pH, dominant vascular plant structure, slope, and broad peatland type (e.g., bog or fen) for each ecosystem type. The frequency of each community type within the ecosystem is also indicated in Appendix 4.

CONSERVATION PRIORITIES

Table 6 lists the highest quality peatlands known in New Hampshire along with their community, conservation status, and comments about each site. These sites were documented through landscape analysis, surveyed during the course of this study, and classified using ordination and other statistical methods. For each community, privately owned, high quality sites should be primary targets for conservation. NH Heritage expects to release quality rank specifications for open peatlands, with complete descriptions of high quality peatland sites, in May 2000.

Continued statewide surveys will advance documentation and classification of peatland sites and increase our confidence that we have accurately selected the most important conservation priorities. Further, more information on the distribution and classification of peatlands outside of New Hampshire is required to better understand the global significance of examples occurring within the state.

Table 6. Preliminary list of high quality peatlands in New Hampshire.
** Highest priority sites; *High priority sites

ECOREGION & SITE	CONSERV. STATUS	COMMENTS
NORTHERN APPALACHIANS		
Umbagog Southeast**	Partial	Calcareous patterned fen with 4 state plant records
South Bay Bog*	No	Large acidic fen complex, including patterned fen, several rare plants
Cannon Mt Cliffs*	Yes (mostly)	Sloping cliff peatland (“sliding fens”), rare plants (G3G4)
Thoreau Falls/Shoal & Ethan Pond Fens*	Yes (mostly)	Unique level and sloping boreal fens/rare plants
Presidential/Mahoosuc/Moriah Ranges*	Yes (mostly)	Subalpine/alpine bogs
Umbagog Northwest*	Yes	Huge acidic fen complex
Pontook Reservoir	No	Large diverse fen/swamp complex
LOWER NEW ENGLAND		
S. Merrimack Valley Sites:		
Ponemah Fen**	No	Large lake-fill kettle fen, *Williamsonia lintneri*
Half Moon/Common Ponds	No	Pond-border kettle fens, *Gaylussacia dumosa*
Ossipee/Pine River Sandplain System:		
Pine River Peatlands/Floodplain (south of Rt. 5/Heath Pond Bog)**	Partial	Huge peatland/streamside/floodplain complex
Pine River Delta West**	No	Large shrub/wooded peatlands with big black ash seepage swamp
Chain of Ponds**	No	High concentration of kettle ponds, including lake-fill fen
Bearcamp Delta**	Partial	Lakeside & kettle fens associated with floodplain

ECOREGION & SITE	CONSERV. STATUS	COMMENTS
		forest & pondshore rarities
Ossipee/Pine River Sandplain System (continued):		
South of Ossipee Lake*	Yes (mostly)	Large, diverse sandplain peatland system
Lost Ponds*	Mostly (state)	Classic kettle hole complex/dwarf-medium heath communities
Duncan Lake Northeast*	No	Huge wooded and shrub fen complex
Broad/Leavitt Bay Kettle*	Partial (town)	Classic kettle hole complex/large floating moss lawns
White Lake Kettles	Partial	Nice set of 3 kettle hole bogs
Other Areas:		
Bradford Bog**	Partial	Moderately large, moderate diversity, very good condition/context, with Atlantic white cedar
Blakes Hill Bog**	No	Large floating mat/lake-fill peatland, excellent black gum swamp, *Williamsonia lintneri*, *Gaylussacia dumosa*
Red Hill Pond**	Partial/yes	Very large lake border and sedge/dwarf heath moss lawns
Lynxfield Pond	No	Moderate size/diversity, excellent landscape context
Mud Pond (Hillsborough)	Yes	Nice pond-border peatland; only site *Helodium paludosum*
Mud Pond (Stoddard)	No	High diversity, moderate size, excellent landscape context
Hubbard Pond	Yes	High diversity, excellent landscape context, several isolated peatlands, dam-controlled
Philbrick Cricenti Bog	Yes	Moderate/high diversity, lake-fill peatland, condition & landscape context good
Berry Pond	No	Large moderately diverse lake border peatland, good condition/landscape context
Northwood Meadows	Yes	Large streamside and small kettle-like peatlands; 1 of 3 sites for *Sphagnum flavicomans*
Brindle Pond	No	Small pond-border muskeg, large streamside, no dam, undeveloped pond, 1 of 2 sites for *Sphagnum riparium*
Trask Swamp	Yes (most of site)	Large acidic fen
Binney Pond	Yes	Low/moderate diversity
NORTH ATLANTIC COAST		
Rochester Heath Bog Complex**	Partial	Diverse system, only site in state for some communities/plants
Spruce Swamp**	No	Huge wooded and shrub peatland/marsh system
Kingston Cedar Swamp Complex:** 1. Powwow River	Partial	Coastal streamside peatland, *Sphagnum platyphyllum*
2. Cedar Swamp Pond	Yes	Classic kettle hole pond-border fen, *Sphagnum flavicomans, Carex striata, Gaylussacia dumosa*
Town Hall Bog	?	Coastal kettle hole
Spruce Hole	Yes?	Coastal kettle hole

MANAGEMENT CONSIDERATIONS

Development is a significant threat to New Hampshire wetlands, including peatlands, particularly in the southern part of the state and along the coast where development activity is greatest. A complicating difficulty in quantifying and qualifying potential impacts, however, is that too often the impacts of a specific activity on a wetland are considered in isolation of the cumulative impacts of development around the wetland. Development threats include fragmentation, habitat displacement and degradation, invasion of non-native species, alteration of flood regimes, and impacts to water quantity and quality (including pollution, eutrophication, and reduction through withdrawal). Logging in and near peatlands may influence hydrologic patterns, nutrient cycles, habitat integrity and fragmentation, and sedimentation.

Because most peatlands are naturally acidic and low in nutrients, they are particularly susceptible to alteration by elevated nutrient inputs associated with development. The related management implication is to increase the size of buffer areas and to limit or control certain activities near these wetland types. Buffers reduce the impact of disturbances outside the system and ensure that other characteristics and processes within the community remain intact. Buffers help protect natural communities from the deleterious effects of increased nutrients, reduced water quality, altered water quantity, invasion by exotic species, windthrow, loss of secondary plant or animal habitat, and future deleterious changes in surrounding land use that may increase threats over the long term. Deciding on an adequate buffer width is complicated, and depends on what impacts are being buffered against, the time frame for protection, and the level of impact or risk of impact that is acceptable. Nutrient-poor ecosystems, such as most peatland complexes, may require larger setbacks than other systems because of their high susceptibility to changes in nutrient concentrations. Direct impacts are typically most serious within 300 ft. (90 m) of wetland areas.

As previously discussed, peatlands typically occur in both limnogenous and topogenous settings, often in topographically defined basins with stagnant or poor drainage and little seepage or alluvial influence. Given these hydrologic limitations, alterations to the hydrology of peatlands may significantly alter the species composition and certain functions of the community. The combined impact of humans and an expanding beaver population on wetlands in recent decades has modified the abundance of early-successional, deeper-water wetland types relative to later successional or shallower water types. Beavers have also dammed wetlands historically not occupied by beavers, including several examples of 400 to 600 year old black gum swamps that were flooded and killed in the early 1990's. Selective control of beaver and human impoundments may be appropriate to preserve unique examples of peatland communities in New Hampshire.

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